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EYE MUSCLES IN TRICHOSURUS

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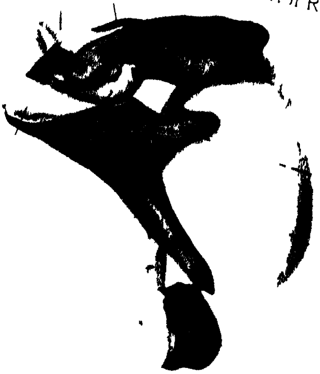

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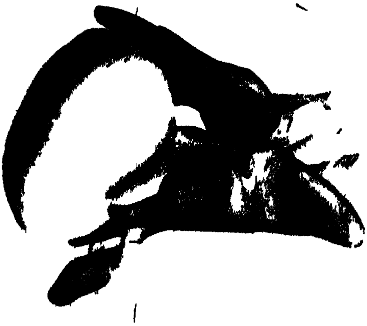

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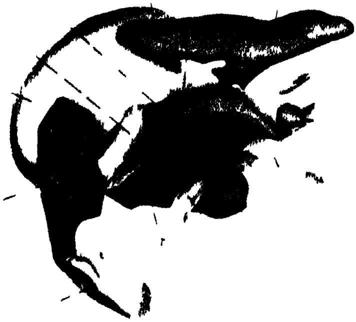

EYE MUSCLES IN TRICHOSURUS

PROCEEDINGS

OF THE

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PAPERS.

24. The Head Cavities and Development of the Eye Muscles in *Trichosurus vulpecula*, with Notes on some other Marsupials.

By Elizabeth A. Fraser, B.Sc. (Lond.), F.Z.S., Embryological Laboratory, Department of Zoology, University of London, University College.

[Received April 23, 1915: Read May 11, 1915.]

(Plates I., II.* and Text-figures 1–26.)

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Introduction.

The following investigation of the head-cavities and development of the eye muscles of *Trichosurus vulpecula* was undertaken at the suggestion of Professor J. P. Hill, whose help and advice I gratefully acknowledge. All the material examined was obtained from Professor Hill's excellent collection of young stages of marsupials.

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* For explanation of the Plates see p. 346.

Cavities in the mesoderm of the anterior (preotic) region of the head, bounded by more or less definite epithelial walls, have been described in many vertebrates, and they are now considered by the majority of observers to represent somites comparable with those of the trunk. They were first observed in Selachians by Balfour (**'78**), later by Milnes Marshall (**'81**), van Wijhe (**'83**), Dohrn (**'90**) (**'04**), and since then by many other investigators in different fishes.

In Amphibians, cavities have been seen by Scott and Osborne (**'79**) in the newt and in the Gymnophionan *Hypogeophis* by Marcus (**'09**). They appear to be absent in *Necturus* (Julia Platt, **'94**); in the frog (Corning, **'99**) and in the toad (Edgeworth, **'99**) the anterior somites in the head are apparently solid, although Goette (**'75**), in his classical work on the development of the toad, appears to refer to them as cavities.

Van Wijhe (**'86**) was the first to point out the occurrence of head-cavities in birds and reptiles. In birds, Rex has more recently studied them in the duck (**'97**) and in the gull (**'01**) (**'05**), Edgeworth (**'07**) in the fowl, and Professor Hill has directed my attention to the occurrence of large premandibular cavities in sections of early emu chicks in his collection.

The conditions in reptiles concern us more closely and may be considered in greater detail. In this class three somites have been observed in the preotic region of the head, of which the first or premandibular develops into a large and conspicuous cavity surrounded by epithelial walls, the cavities of either side at some time of their development being usually connected across the middle line by a transverse canal as in fishes. The second and third somites are small and more difficult to determine, and observers differ considerably in their accounts of them. Van Wijhe (**'86**) did not discover a second somite in *Lacerta* and he describes the third somite as solid; Hoffmann (**'90**), on the other hand, finds three hollow somites behind the premandibular, but whether the last two both belong to the third head somite or whether they correspond to somites three and four of fishes, he was unable definitely to decide. Again in *Lacerta*, Corning (**'99**) recognises the third somite but no similar second somite, the m. obliquus superior, which usually develops from the latter, here being described as arising from the dorsal part of the primordium of the trigeminal musculature which grows out over the eye. In *Anguis fragilis*, both the second and third somites were seen by Oppel (**'90**), each of which contained a small central cavity, but the second was much less distinct than the third. In the Chelonia the same somites are present, but whereas in *Emys lutaria*, according to Filatoff (**'07**), the third is solid, in *Chelydra serpentina*, described by Johnson (**'13**), both second and third possess a distinct cavity round which the cells are arranged in a radial manner.

The occurrence of large anterior head-cavities followed by corresponding structures behind them, has led to much discussion on the metamerism of the vertebrate head. As one advances in the scale of vertebrates, however, the segmentation in the mesoderm of the preotic region of the head becomes more and more obscure, until in the Mammalia only traces remain of a former metameric condition. No definite head-cavities have ever been observed in mammals, although probable remnants of these have been found in man by Zimmermann (**'98**). In the rabbit, although the first head somite arises much as in reptiles from the fore-end of the alimentary canal as a solid outgrowth (Corning **'99**), or as a hollow one soon becoming solid (Edgeworth **'11**), it never acquires a cavity as in lower vertebrates but in later stages forms a small solid mass of cells behind the optic cup on each side, difficult to distinguish from the surrounding tissue. Reuter (**'97**), who has studied the pig, sees there no signs of primitive segments in the head and considers the eye muscles as a completely independent formation arising from an accumulation of mesenchyme cells; his observations, however, begin at a late stage and no early embryos are described.

It was first noted by Milnes Marshall (**'81**) in Elasmobranchs and is now well established, that the walls of the premandibular cavity give rise to four muscles of the eye, the mm. recti superior, inferior and internus and the m. obliquus inferior, all innervated by the oculomotor nerve; that the second head somite contributes the m. obliquus superior supplied by the trochlear nerve, while the third furnishes the m. rectus externus and, in reptiles and mammals, the m. retractor bulbi, both these muscles being supplied by the abducens nerve.' We have an exception to the usual conditions in *Petromyzon*, where the innervation of the muscles is peculiar. According to Furbringer (**'75**, p 70), "Die Innervation der Augenmuskeln anlangend besteht bei den Petromyzonten die Eigenthumlichkeit, dass, wahrend der Oculomotorius der Fische sämmtliche Augenmuskeln mit Ausschluss des Rect. ext. und Obliq. sup. versorgt, hier der Rect. inf. nicht vom Oculomotorius, sondern vom Abducens innervirt wird, so dass also der Abducens 2 Augenmuskeln versorgt. Dieses Verhalten ist vielleicht dahin zu deuten, dass der Rect. int. den vereinigten Rect. int. und Rect. inf. entspricht und dass in gleichem Masse, wie diese beiden Muskeln sich späterhin in 2 gesondert, der Rect. inf. mit dem Rect. ext. verschmolzen, einen einzigen durch den Abducens innervirten Muskel vorstellend."

The conditions in Amphibia also do not seem to coincide with those in other groups and the views of different authors are very conflicting. Marcus (**'10**) has studied the Gymnophiona in some detail, and according to his account of *Hypogeophis* the mandibular somite, at first connected by a transverse bridge with its fellow of the opposite side, develops into a large cavity surrounded by a single layer of epithelial cells lying postero-dorsally to the eye, and from which a cell-strand grows down into the mandibular arch (see his fig. V, p. 139, Marcus, '09). The premandibular cavity, which is small and has also in early stages a connecting median portion, partly degenerates, but a small part moves up to the mandibular cavity and completely unites with the rostral side of the latter. All the eye muscles, except the m. rectus externus derived from the third somite, take their origin from the mandibular cavity which is innervated by the oculomotor and perhaps also by the trochlear nerve. Marcus ('10) further states (p. 409):—"Daher glaube ich, das, wenn auch Prämandibularzellen sich mit der Mandibularmasse vereinigt haben, nicht deswegen der Oculomotorius die Mandibularhöhle innervirt, sondern dass er ganz primär der zugehörige Nerv ist. Dies ergiebt sich, ausser durch die naive Betrachtung, auch durch folgende Ueberlegung. Aus dem rostralsten Teil der Mandibularhöhle entwickelt sich der Musc. obliquus superior, also ein vom Trochlearis innervierter Muskel. Die Zellmasse, woraus er sich entwickelt, glaube ich aus der Prämandibularmasse ableiten zu können. Exackt beweisen kann ich diese Behauptung freilich nicht, weil bei der Muskelbildung die Mandibularhöhle schon mesenchymatös war, also die Muskelbildung nicht so scharf wie bei Selachiern verfolgt werden kann; aber aus der Topographie der Gebilde ergibt es sich, das zur Bildung des Musc. obliquus superior wie bei Selachiern so auch bei *Hypogeophis* dieser Abschnitt der Mandibularhöhle verwendet wird."

Although many authors have given accounts of the origin of these preotic somites and of the first development of the eye muscles from their walls, few have traced in detail the further growth of these muscles until their adult position is reached. In reptiles and mammals this latter growth is more difficult to follow owing to the development of the m. retractor bulbi. The most complete account in reptiles is that of *Chelydra serpentina* by C. E. Johnson ('13), and the only description in mammals is that of Reuter's paper ('97) on the pig, above mentioned. The following observations on the marsupial *Trichosurus vulpecula* will therefore be of some interest.

MATERIAL.

The material examined comprises twelve stages of *Trichosurus vulpecula*, eight embryos and four pouch young of *Phascolarctos cinereus*, five embryos of *Phascolomys mitchelli*, an embryo and a fœtus of *Macropus*, five embryos and one pouch young of *Perameles*, one embryo of *Didelphys* and a good series of *Dasyurus*.

Two wax-plate models of the optic cup and primordia of the eye muscles were made and are reproduced on Plates I. & II. I am much indebted to Miss E. A. Steele for her excellent coloured drawings of these models. The terminology of the arteries and veins in the head has been adopted from Grosser's account of the development of the vascular system in the Chiroptera ('01) and also from the description of the development of the veins of the head in reptiles by Grosser and Brezina (**'95**).

THE EYE MUSCLES OF THE ADULT.

Adult specimens of *Trichosurus* and *Dasyurus* were examined, and the usual eye muscles, including a well-developed m. retractor bulbi, were found to be present. In 1902, Corning (**'02**) described in some detail the eye muscles of the cat, and his account is generally applicable to the recti and oblique muscles of the marsupial. The only noteworthy difference is in regard to the form of the m. rectus externus which in marsupials has a double origin, the two portions uniting to have a common insertion on the eyeball.

The m. retractor bulbi shows considerable variation in different mammals. When present, it always arises further caudally than the m. rectus externus but enters the orbit together with the mm. recti and the m. obliquus superior, and its insertion in the bulbus lies nearer the optic nerve than the other muscles. According to Motais (**'87**), who has studied this muscle in many mammals, the m. retractor bulbi attains its maximum development in ruminants; he also observed its relatively large size in the opossum. He further states, p. 56: "Le muscle choanoïde peut offrir un ou plusieurs interstices celluleux qui le divisent en deux ou plusieurs parties. Ces interstices sont larges dans les carnivores et séparent le muscle en quatre faisceaux bien distincts. Ordinairement, les lignes de séparation sont moins nettes; dans les solipèdes et les ruminants, les bords des deux divisions du muscle s'envoient réciproquement des fascicules . . . . Dans le porc, on ne trouve qu'un seul interstice assez large au milieu du muscle droit inférieur." Similar conditions to those in the pig are found in rodents; the same author, in his description of the rabbit, p. 206, says: "Il [le muscle choanoïde] forme un cône régulier qui n'est interrompu que par un seul interstice celluleux situé au-dessous du muscle droit supérieur. Cet interstice se prolonge jusqu'à l'insertion bulbaire du nerf optique et le long du nerf lui-même, jusqu'au trou optique." In the cetaceans (Weber, **'86**) the same variations occur; here again, the muscle may be present as an almost complete circular sheet surrounding the optic nerve or it may be divided into four parts, each more or less united by connective tissue.

In *Trichosurus* and *Dasyurus*, as in other mammals, the m. retractor bulbi has a more deeply seated origin than the other muscles. It arises from the basisphenoid and passes forwards to enter the orbit between the two portions of the m. rectus externus. Surrounding the optic nerve, it extends outwards as a muscular sheet which gradually increases in circumference up to its insertion round the inner side of the eyeball within the recti muscles. Although appearing as a completely closed cone, the two edges of the sheet are not fused along the anterior side of the nerve just behind the m. rectus internus.

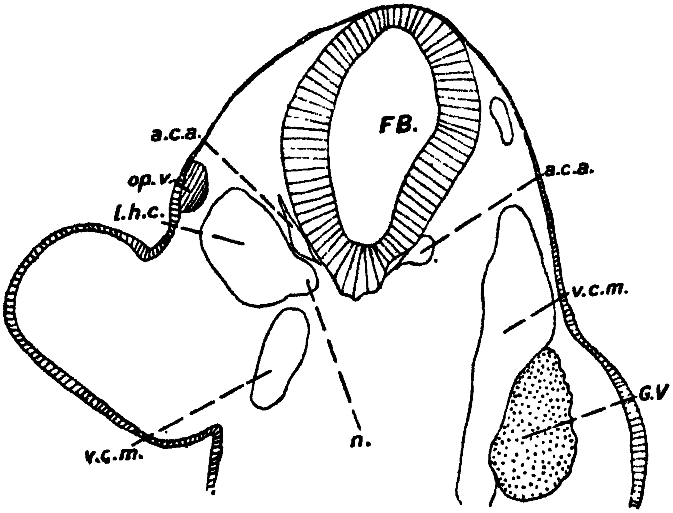
DESCRIPTION OF MATERIAL.

Trichosurus vulpecula. Embryo of G.L. 5 mm. (=Stage I. *a*, *b* & *c*)*. (Text-figs. 1, 2.)

This stage is represented by three embryos, *a* (δ '97), *b* (IA. '01), and *c* (I. '01), of which (*a*) and (*c*) are cut horizontally and (*b*) longitudinally.

The cavity of the optic vesicle is flattened by the thickening and partial invagination of its lateral wall, and it is connected with the brain by a hollow stalk. The ectoderm opposite the vesicle is thickened.

Text-figure 1.



Trichosurus vulpecula, G.L. 5 mm. (δ '97).

Horizontal section through the head (S 3-4-5), somewhat oblique, passing through the premandibular head-cavity of the left side. × 75 and reduced by ⅓.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *G.V.*=trigeminal ganglion. *l.h.c.*=left head-cavity. *n.*=portion of cavity constricted off from the rest. *op.v.*=optic vesicle. *v.c.m.*=vena capitis medialis.

There are two large and conspicuous head-cavities, one on each side immediately posterior to and on the medial side of the optic vesicle, situated ventro-laterally to the fore-brain; between the cavity, and the brain runs the anterior cerebral artery. The cavity is lined by a single layer of epithelial cells which is more attenuated on the side farthest from the brain, where it cannot everywhere be distinguished in the sections. The shape of the cavity varies slightly in the three embryos, being obliquely rectangular in cross-section in (*a*) (text-fig. 1, *l.h.c.*), where on the left side it measures ·26 mm. in a dorso-ventral direction, ·31 mm. antero-posteriorly and ·32 mm. transversely; but it is more oval in (*b*), and tapers somewhat towards the eye (text-fig. 2, *r.h.c.*). On both sides in (*a*) a small medial portion is marked off from the main body of the cavity by a constriction, the upper part of which can just be seen in text-fig. 1, *n*. No such condition is present in (*b*) or (*c*), although on the left side of the former there is an incomplete partition across the middle of the cavity; the division in this case, however, may not have the same significance.

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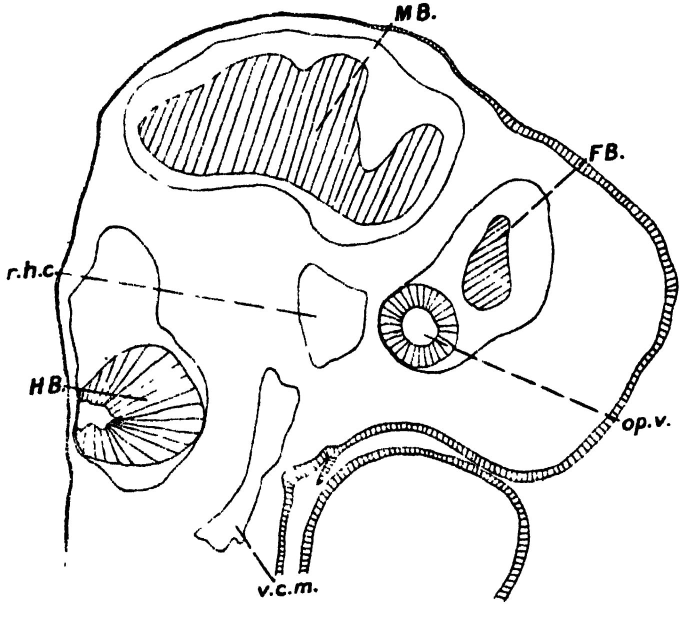
* *Vide* Fraser and Hill: "The Development of the Thymus, Thyroid and Epithelial Bodies in *Trichosurus vulpecula*," Phil. Trans. Roy. Soc. 1915.

Text-figure 2.



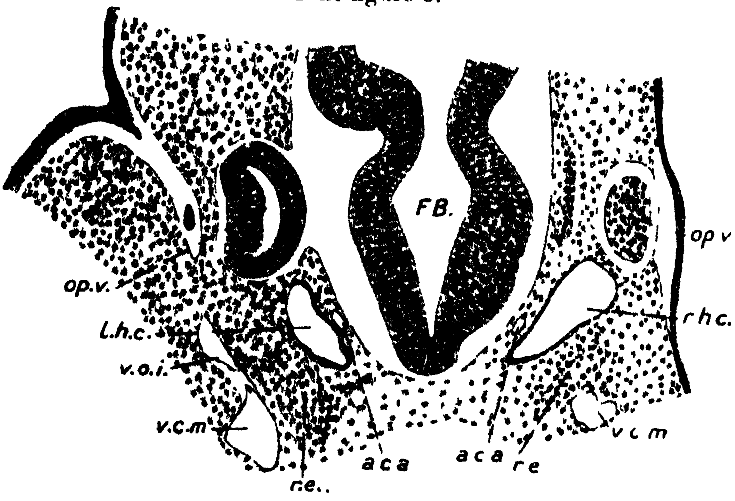
Trichosurus vulpecula, G.L. 5 mm. (IA. '01).

Longitudinal section (S 2-1 13) passing through the premandibular head-cavity of the right side. × 75 and reduced by ⅓.

FB.=fore-brain. *HB.*=hind-brain. *MB.*=mid-brain. *op.v.*=optic vesicle. *r.h.c.*=right head-cavity. *v.c.m.*=vena capitis medialis.

In embryo (*c*), lying obliquely along the postero-lateral wall of the cavity, on the inner side of the vena capitis medialis, is a slightly more condensed portion of the mesenchyme, representing the third or hyoidean somite and constituting the primordium of the abducens muscle-mass. It runs forwards and laterally just below the origin of the vena cerebralis anterior into another mass of loosely connected cells, which extends downwards round the lateral side of the vena capitis medialis to become united below with the maxillo-mandibular mesenchyme. On its anterior side this group of looser cells, to which in following stages I have given the name of the intermediate mass and which represents the second or mandibular somite, projects slightly forwards anterior to the cavity: this projection, as we shall see later, is the first indication of the primordium of the m. obliquus superior. The intermediate mass is, at the same time, connected with the postero-lateral wall of the cavity for three or four sections. The limits of the complex formed by the intermediate and abducens masses are difficult to determine accurately, as they are not easily distinguished from the surrounding mesenchyme and in embryo (*a*) are still more indefinite. In the longitudinal series, a distinct but small elongated collection of cells stretches along the posterior border of the cavity, apparently representing the abducens mass, but no connection with any maxillo-mandibular mesenchyme is recognisable.

Text-figure 3.



Trichosurus vulpecula. G.L. 4·5 mm. (β '98).

Transverse section (S 3–6–13) passing through the premandibular head-cavity on each side. The sections are rather oblique, the cavity of the left side being cut nearer its ventral end. The anterior portion of the abducens muscle-mass lies posterior to the cavity. × 110 and reduced by ⅓.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *l.h.c.*=left head-cavity. *op.v.*=optic vesicle. *r.e.*=anterior portion of abducens muscle-mass. *r.h.c.*=right head-cavity. *v.c.m.*=vena capitis medialis. *v.o.i.*=vena orbitalis inferior.

The Gasserian ganglion is large and the mandibular branch of the trigeminal nerve is already well developed. The oculomotor nerve runs from the mid-brain anteriorly for a short distance but does not reach the head-cavity.

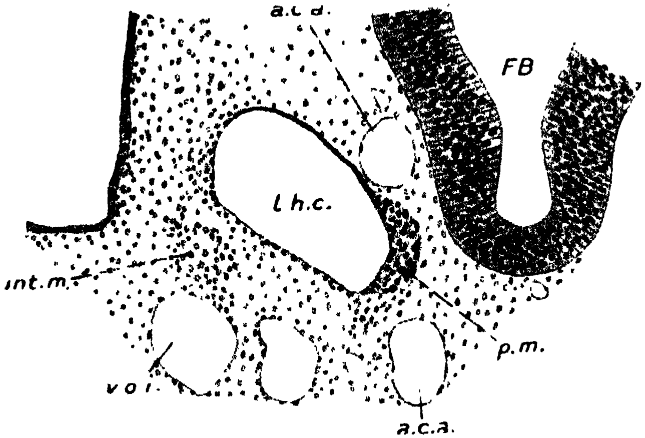
Another embryo (*β* '98) measuring 4·5 mm. (=Stage II *a*) at its greatest length, may be mentioned here. It is cut transversely and almost at right angles to the last and is slightly older, the optic vesicle being still further invaginated.

The head-cavities are narrow from side to side and have the form in the sections of an elongated triangle, the long pointed end of which runs ventrally and medially (text-fig. 3, *r.h.c.*). They are lined by a single layer of epithelial cells which can be distinguished all round the cavity but which, on the side next the optic vesicle and extending round this side laterally for a short distance, is considerably attenuated. The exact limits of the abducens muscle complex are again very indefinite (text-fig. 3, *r.e.*).

Embryo of G.L. 7 mm. (*a* '97) (=Stage III.).
(Text figs. 4–6.)

The cavity of the optic vesicle is very narrow, the outer or retinal layer being much thickened and well invaginated and the adjacent ectoderm now forms a rounded solid inbulging, the primordium of the lens.

Text figure 4.



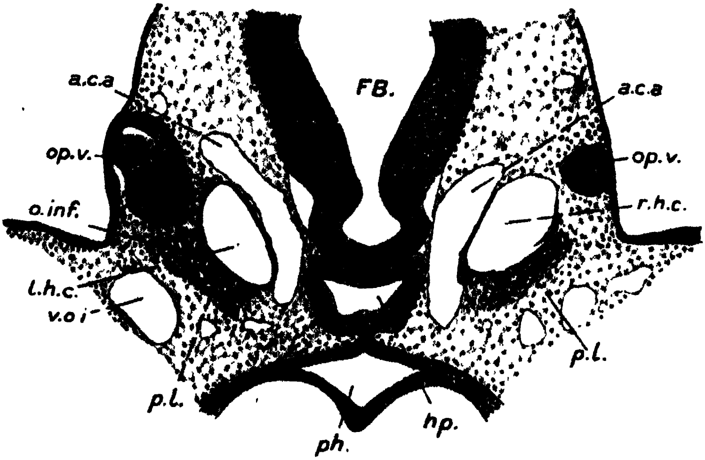
Trichosurus vulpecula. G.L. 7 mm. (*a* '97).

Horizontal section through the head (S 3 2-11), passing above the optic vesicle and through approximately the middle of the head-cavity of the left side (*l.h.c.*), to show the proliferation from postero-medial wall of the cavity (*p.m*). The ventral end of the intermediate mass is seen postero-laterally to the cavity. × 110 and reduced by $\frac{1}{4}$.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *int.m.*=intermediate mass. *v.o.i.*=vena orbitalis inferior.

The premandibular head-cavity has only increased slightly in size but changes are to be seen in its walls. About half-way down the cavity on the postero-medial side, the wall has thickened and is now composed of several layers of cells (text-fig. 4, *p.m.*); immediately ventral to this and on the postero-lateral side occurs a much more extensive proliferation, which extends down as far as the end of the cavity but does not involve the extreme ventral wall (text-fig. 5, *p.l.*). At its lower end, however, a part of this thickening stretches out laterally behind the bulbus and forms the first indication of the m. obliquus inferior (text-fig. 5, *o.inf.*). On the left side, the two proliferations appear to be separate from each other, but on the right the more dorsal one extends round at its lower end to join the larger ventral. Except where proliferation is proceeding the wall of the cavity is very thin: on the side next the brain it consists of a single but perfectly definite epithelial layer, but on the side next the optic cup it is much less definite (text-figs. 4 & 5).

Text-figure 5.



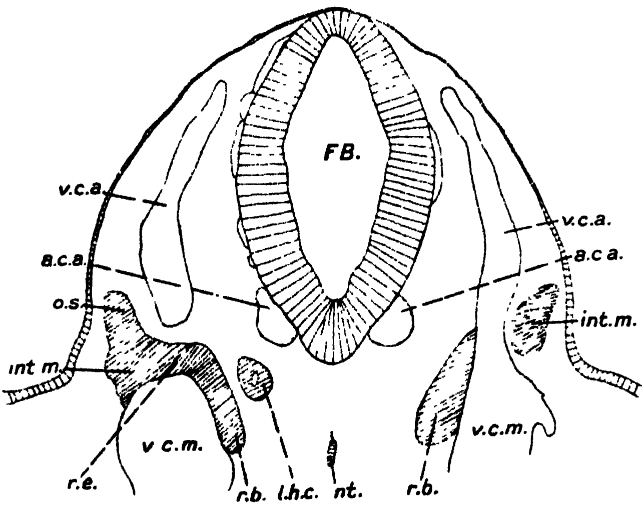
Trichosurus vulpecula. G.L. 7 mm. (*a* '97).

Horizontal section through the head (S 3-3-9), passing through the dorsal portion of the optic vesicle (*op.v.*) and the ventral portion of the head-cavities (*l.h.c.* & *r.h.c.*), to show the proliferation from the postero-lateral wall (*p.l.*). The primordium of m. obliquus inferior (*o.inf.*) is seen on the left side. × 75 and reduced by ⅓.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *hp.*=hypophysis. *ph.*=pharynx. *v.o.i.*=vena orbitalis inferior.

The primordium of the abducens muscle-mass consists of a postero-dorsal portion which lies along the medial side of the vena capitis medialis (text-fig. 6, *r.b.*) and which, at its anterior end, runs ventrally outwards to join with the larger anterior portion of the mass (text-fig. 6, *r.e.*). The latter, whose dorsal side surrounds the root of the vena cerebralis anterior, lies anterior to the vena capitis medialis and extends half-way down the head-cavity close to the postero-lateral wall of the latter, its lateral end running into the intermediate mass, the limits of the two being indistinguishable (text-fig. 6, *int.m.*, and also the ventral end in text-fig. 4, *int.m.*). The intermediate mass itself, which is composed of more loosely connected cells, passes on the one hand, forwards into a mass of condensed mesenchyme lying above the optic vesicle on the outer side of the ophthalmic nerve, this portion representing the primordium of the m. obliquus superior (text-fig. 6, *o.s.*); and on the other hand, backwards and

Text-figure 6.



Trichosurus vulpecula. G.L. 7 mm. (*a* '97).

Horizontal section (somewhat diagrammatic) through the head (S 3-1-11), showing the posterior (*r.b.*) and anterior (*r.e.*) portions of the abducens muscle-mass of the left side, which extend in front of the vena capitis medialis (*v.c.m.*), just ventral to the vena cerebralis anterior (*v.c.a.*), to unite with the intermediate mass (*int.m.*). The primordium of the m. obliquus superior (*o.s.*) is seen as a forward outgrowth from the intermediate mass. Owing to the obliquity of the sections, the right side is cut at a more dorsal level than the left and only shows the posterior portion (*r.b.*) of the abducens mass lying medial to the vena capitis medialis (*v.c.m.*) and the vena cerebralis anterior (*v.c.a.*). × 75 and reduced by $\frac{1}{3}$.

a.c.a.=arteria cerebri anterior. *l.h.c.*=left head-cavity. *nt.*=notochord.

downwards lateral to the vena capitis medialis and is loosely connected with the maxillo-mandibular muscle-mass, the connection here not being well seen. The union of the intermediate mass with the postero-lateral wall of the cavity is most probably again present.

The oculomotor nerve is now thicker and its distal end terminates dorso-laterally to the head-cavity.

From the Gasserian ganglion arise a well-developed mandibular nerve, a small maxillary branch and an ophthalmic nerve.

The abducens is here seen for the first time. It leaves the mid-brain by many fine fibres which unite and run forwards parallel to the side of the brain for a short distance.

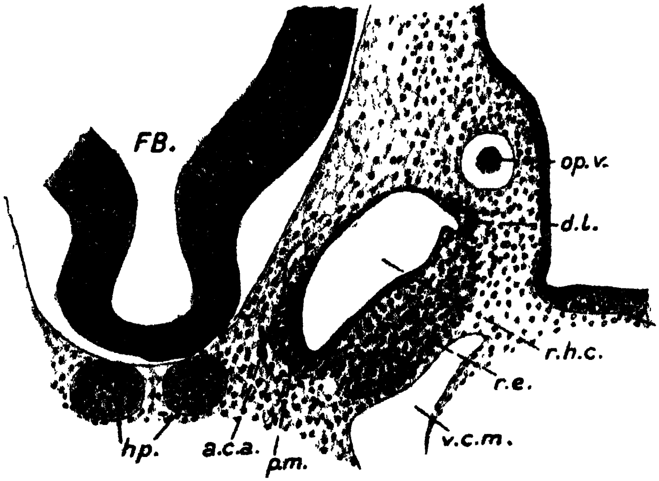
Another example of this stage, which measures 7·5 mm. (XIX. '04) (=Stage IV.), presents almost the same features. Although the sections are cut in the same direction, that is horizontally through the head, the head-cavity in section is more triangular and less elongated so that its area is larger than in the 7 mm. embryo above described. The postero-medial and postero-lateral proliferations form one thickening and the vena cerebralis anterior appears to be only slightly surrounded by the anterior portion of the abducens muscle-mass.

The conditions in this embryo, however, are difficult to make out accurately.

Embryo of G.L. 6 mm. (II. '01) (=Stage V.).
(Text-figs. 7 & 8.)

The cavity of the optic vesicle is still further reduced and the lens is almost separated off from the ectoderm which is closing over it.

Text-figure 7.



Trichosurus vulpecula. G.L. 6 mm. (II. '01).

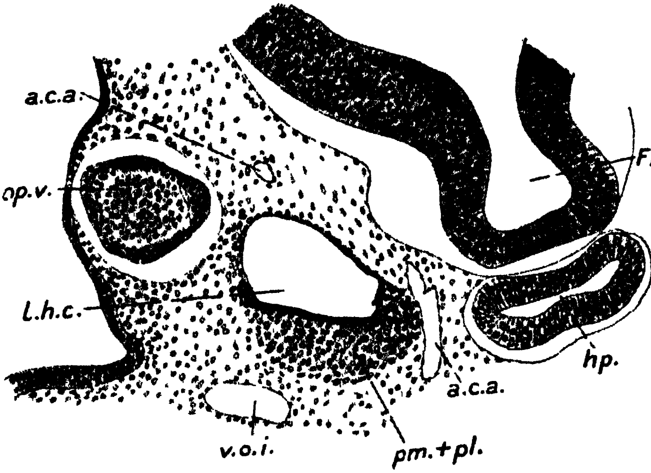
Horizontal section through the head (S 2-4-2), passing just above the middle of the head-cavity of the right side (*r.h.c.*), and showing the proliferating bud on the dorso-lateral wall (*d.l.*) and the thickening on the postero-medial wall (*p.m.*). The anterior portion of the abducens muscle-mass (*r.e.*) lies posterior to the head-cavity and in front of the vena capitis medialis (*v.c.m.*). × 110 and reduced by ¼.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *hp.*=hypophysis. *op.v.*=optic vesicle.

The premandibular head-cavity is large and conspicuous on each side; although at its widest it is only slightly smaller than that of the 7 mm. embryo, the ventral portion is reduced, perhaps owing to further proliferation of the walls.

The proliferation of the postero-medial wall is more extensive; it begins more dorsally and, as the cavity narrows ventrally, it extends round on to the postero-lateral wall, the two thickenings forming one mass (text-fig. 8, *pm.+pl.*). The thickened area is continued on to the extreme ventral wall from which a solid mesodermal mass, the m. obliquus inferior, hangs down below the cavity posterior to the optic cup and tapers at its lower end.

Text-figure 8.



Trichosurus vulpecula. G.L. 6 mm. (II. '01).

Horizontal section through the head (S 2-4 8), passing through the dorsal region of the optic vesicle (*op.v.*) and the ventral portion of the left head-cavity (*l.h.c.*), to show the now united postero-medial and postero lateral proliferations from the wall (*pm.+pl.*). × 110 and reduced by $\frac{1}{4}$.

a.c.a. = arteria cerebri anterior. *FB* = fore-brain. *hp.* = hypophysis.
v.o.i. = vena orbitalis inferior.

At this stage for the first time, on the dorso-lateral region of the cavity on both sides, the wall shows a distinct, though not very extensive thickening which originates as a bud growing out of the cavity (text-fig. 7, *d.l.*). This bud is the primordium of the m. rectus superior.

The cavity is lined by a single layer of cells except where the wall is proliferating.

The abducens muscle complex has increased considerably in size and is more distinct than in our earlier stages. The much larger anterior portion, still connected on its lateral side with the intermediate mass, lies very close behind the head-cavity and in front of the Gasserian ganglion, being separated from the latter by the vena orbitalis inferior (text-fig. 7, *r.e.*); it extends down along the upper two-thirds of the cavity to the region where the postero-lateral proliferation begins. The smaller postero-dorsal portion runs back as before on the medial side of the vena capitis medialis.

The primordium of m. obliquus superior has now grown further forwards from the intermediate mass and reaches anteriorly beyond the distal end of the ophthalmic branch of the trigeminal nerve, on the outer side of which it lies. The connection of the intermediate mass with the maxillo-mandibular mesenchyme is most probably present but could not definitely be made out in this embryo; the mass is again joined with the dorso-lateral corner of the cavity for about three sections.

The oculomotor nerve is stronger and, running down ventrally on the medial side of the vena capitis medialis, now reaches the head-cavity and appears as a small nerve between the wall of the latter and the anterior portion of the abducens muscle-mass; its distal end soon disappears and can only be followed for a short distance alongside the cavity.

The abducens nerve is now well developed and runs forwards on the inner side of the Gasserian ganglion, but it is not very much longer than at the last stage.

Embryo of G.L. 7·75 mm. (XX. '04) (=Stage VI.).

As regards the development of the eye and the muscle-masses this stage is very similar to the last, and only a few observations need be made upon it.

The optic vesicle is not so flattened as at 6 mm. and the lens is still joined with the ectoderm.

The premandibular head-cavity is smaller and pear-shaped, its wider side lying next the eye, and the posterior proliferations are more extensive though the thickening on the ventral wall does not appear to be so marked. No dorso-lateral proliferation was recognised.

The abducens nerve now runs into the pointed posterior end of the dorsal portion of the abducens muscle-mass.

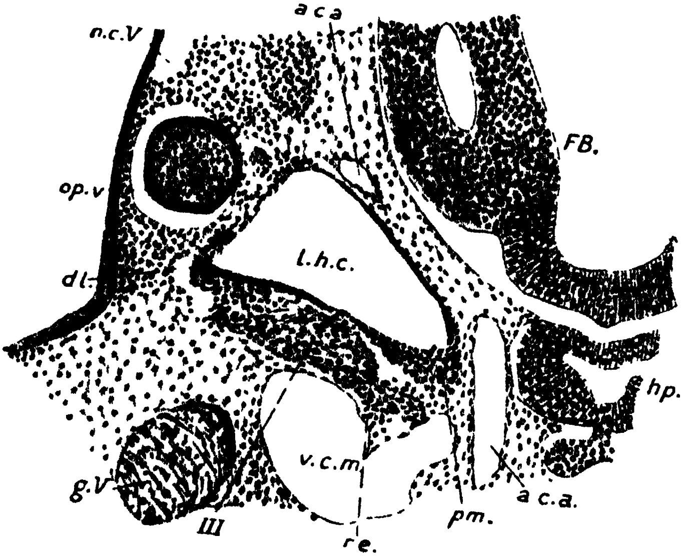
Embryo of G.L. 7·25 mm. (=Stages VII. & VIII. *a* & *b*). (Text-figs. 9–13.)

In this next stage there are three embryos, *a* (III. '01), *b* (XII A. '02) and *c* (XII. '02), each measuring 7·25 mm. at its greatest length. Although in many particulars (*a*) is the youngest of the three and (*c*) is slightly older than (*b*), in respect of the eye-muscle primordia very little difference exists between them.

The invagination of the optic vesicle has advanced still further, the cavity being reduced to a narrow slit, but the optic stalk still contains a wide lumen. The lens is closed off from the ectoderm and forms a hollow vesicle with thickened walls and a central cavity.

In (*a*) the premandibular head-cavity has attained its maximum size and, at its widest, has roughly the form in horizontal section of a right angled triangle (text-fig. 9, *l.h.c.*) measuring ·48 mm. transversely × ·37 mm. antero posteriorly × ·23 mm. dorso-ventrally. In (*b*) and (*c*) the cavity is smaller than in (*a*), but is still large, the difference being due mainly to a reduction in the antero-posterior width, which here is only ·12 mm.

Text-figure 9.



Trichosurus vulpecula. G.L. 7·25 mm. (III. '01).

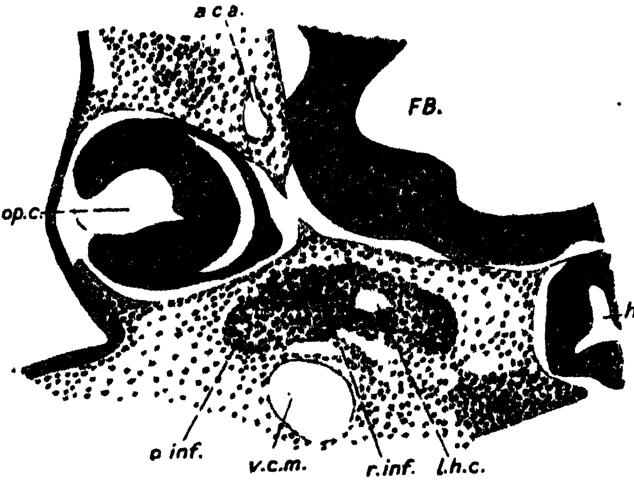
Horizontal section through the head (S 4–4 1), passing through the dorsal region of the optic vesicle (*op.v.*) and through the middle of the left head-cavity (*l.h.c.*). The ventral portion of the proliferating bud on the dorso-lateral wall (*dl.*) and the thickening on the postero-medial wall (*pm.*) are shown, and also the anterior portion (*r.e.*) of the abducens muscle-mass lying posterior to the cavity. Between the latter and abducens muscle-mass runs the oculomotor nerve (III.). × 110 and reduced by ⅓.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *hp.*=hypophysis. *g.V.*=Gasserian ganglion. *n.c.V.*=Naso-ciliary branch of the trigeminal nerve. *v.c.m.*=vena capitis medialis.

The thickening of the posterior wall is still more marked than in the preceding stage and, joining with the prominent ventral proliferation which now forms a conspicuous outgrowth (text-figs. 10, 12, & 13, *o.inf.*), extends out ventro-laterally to taper off behind and somewhat below the eye. This portion, already indicated in the 7 mm. and 6 mm. embryos, develops into the future m. obliquus inferior.

On the medial side of the primordium of the m. obliquus inferior at the lower end of the cavity is a darker patch of cells (text-fig. 10, *r.inf.*), the first indication of the m. rectus inferior, which therefore apparently arises from the lateral side of the postero-ventral wall just medial to the m. obliquus inferior.

Text-figure 10.



Trichosurus vulpecula. G.L. 7·25 mm. (III. '01).

Horizontal section through the head (S 5-1 2), passing through the optic cup (*op.c.*) above the optic stalk and through the extreme ventral end of the left cavity (*l.h.c.*). to show the primordium of the m. obliquus inferior (*o.inf.*) and, just medial to the latter, the region from which the m. rectus inferior (*r.inf.*) takes its origin. × 110 and reduced by ⅓.

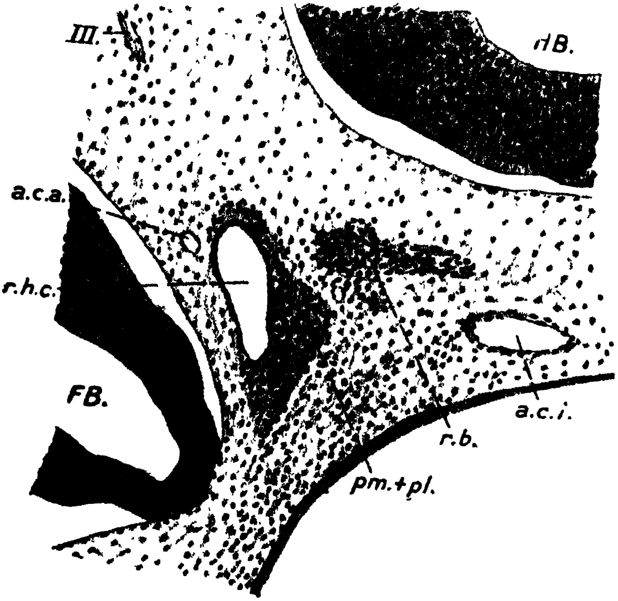
a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *hp.*=hypophysis.
v.c.m.=vena capitis medialis.

The muscle-bud from the dorso-lateral wall, representing the primordium of the m. rectus superior, is less conspicuous than the other proliferations. It is present on both sides, projecting behind the dorsal part of the optic cup (text-fig. 9, *dl.*); on the right side in (*c*) the bud is less distinct, probably owing to the further thickening of its posterior wall and to the commencing separation of the dorso-lateral portion of the cavity from the rest.

A distinct epithelial layer can only be distinguished on the side next the fore-brain.

The abducens muscle-mass still consists of two portions. The dorsal portion (text-fig. 11, *r.b.*) stretches still further back on the medial side of the vena capitis medialis as a narrow prolongation into which runs nerve VI and becomes continuous with the anterior part. The latter turns round almost at right angles and runs out laterally immediately behind the postero-lateral wall of the head-cavity (text-figs. 9 & 12, *r.e.*). It tapers ventrally, its lower outer end lying close against the inner portion of the m. obliquus inferior, the two being connected through two or three sections.

Text-figure 11.



Trichosurus vulpecula. G.L. 7·25 mm. (XII A. '02).

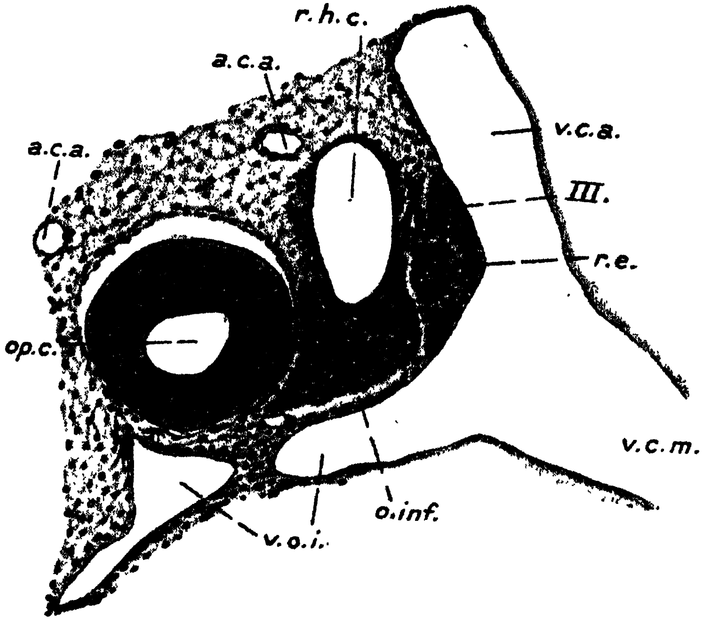
Longitudinal section (89-3-9), passing through the medial side of the right head-cavity (*r.h.c.*) to show the proliferation from the posterior wall (*pm.+pl.*) and the postero-dorsal portion (*r.b.*) of the abducens muscle-mass. × 110 and reduced by ¼.

a.c.a.=arteria cerebri anterior. *FB.*=fore-brain. *a.c.i.*=arteria carotis interna. *HB.*=hind-brain. *III.*=oculomotor nerve.

The trigeminal nerve has now both a supra-orbital and a naso-ciliary branch, running forwards above the bulbus, the naso-ciliary lying on the outer side of the dorsal end of the cavity (text-figs. 9 & 13, *n.c.V.*).

The primordium of the m. obliquus superior is best seen in the longitudinal series (text-fig. 13, *o.s.*). It begins as a collection of cells above and anterior to the optic cup and, extending along the ventral and ventro-lateral sides of the supra-orbital nerve, it passes backwards and downwards as a solid band of mesenchyme through which runs the naso-ciliary branch of the trigeminal just where this branch joins the ophthalmic. This band continues ventrally, anterior to the Gasserian ganglion, to join the intermediate mass, the latter being connected posteriorly by a thin stream of cells round the antero-ventral side of the same ganglion with the maxillo-mandibular muscle-mass. No union with the maxillo-mandibular mesenchyme can be traced in either

Text-figure 12.



Trichosurus vulpecula. G.L. 7·25 mm. (XII A. '02).

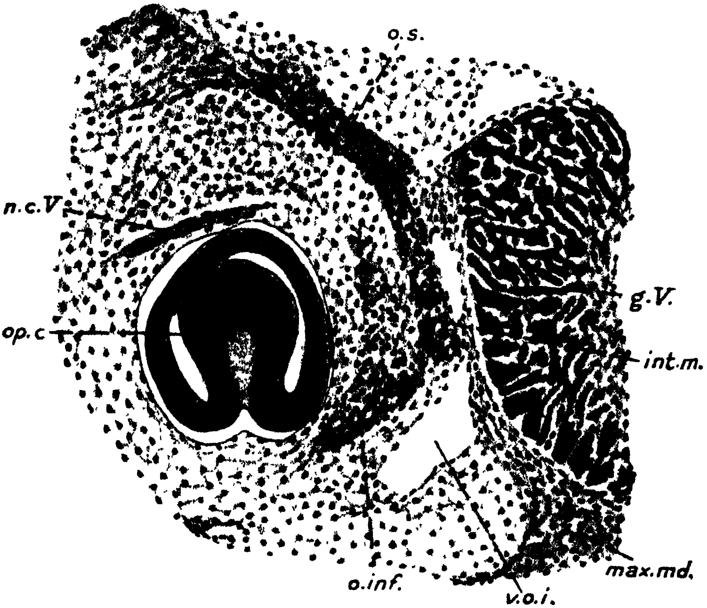
Longitudinal section (S 10-3-1), passing about half-way through the right head-cavity (*r.h.c.*), to show the primordium of the m. obliquus inferior (*o.inf.*) and the anterior portion (*r.e.*) of the abducens muscle-mass lying behind the cavity and immediately in front of the vena capitis medialis (*v.c.m.*) and the vena cerebralis anterior (*v.c.a.*). The oculomotor (III.) runs down between the cavity and the abducens mass. × 110.

a.c.a. = arteria cerebri anterior. *op.c.* = optic cup. *v.o.i.* = vena orbitalis inferior.

of the transverse series, but the intermediate mass in all three embryos is still joined with the dorsal outer end of the anterior portion of the abducens complex. In the transverse series (*c*) the intermediate mass appears to have lost its connection with the m. obliquus superior and is apparently degenerating.

The oculomotor nerve, descending almost directly ventrally from the mid-brain, runs close to the postero-lateral wall of the cavity between the latter and the abducens mass (text-figs. 9 & 12, III.). At its distal end it breaks up into many fibres which extend into the postero-lateral proliferation near the point of origin of the m. obliquus inferior.

Text-figure 13.



Trichosurus vulpecula. (XII A. '02.)

Longitudinal section (S 11 ·1 1), passing through the lateral wall of the cavity and the primordium of the m. obliquus interior (*o.inf.*). The primordium of the m. obliquus superior (*o.s.*) extends forwards from the intermediate mass (*int.m.*) as a solid band of cells dorsal to the optic cup (*op c.*). × 110.

g.V.=Gasserian ganglion. *max.md.*=maxillo-mandibular mesenchyme. *n.c.V.*= naso-ciliary branch of the trigeminal nerve. *v.o.i.*=vena orbitalis inferior.

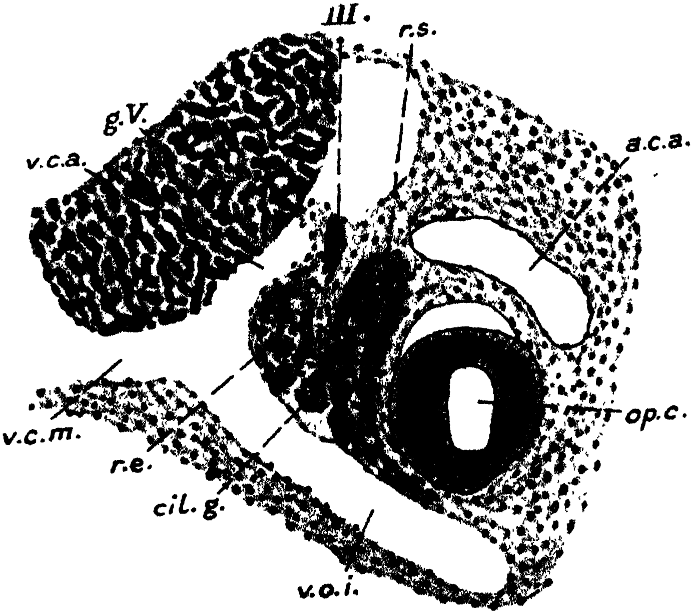
Embryo of G.L. 8·5 mm. ('97 & IV.'01) (=Stage IX. *a* & *b*). (Text-figs. 14-16.)

This stage, which measures 8·5 mm. and of which we have two embryos, (*a*) and (*b*), is a good deal more advanced than the preceding one.

The primary optic vesicle still shows a well-marked cavity in the region of attachment of the optic stalk which is still hollow, and pigment is beginning to form in its outer wall. The inner wall of the lens is thickened, its cavity being reduced to a narrow semicircle, and the eyelid has begun to develop as a fold of the ectoderm on the ventral and posterior sides of the optic cup.

The premandibular cavity is now represented by a mass of mesoderm in which are situated a few cleft-like spaces lying obliquely on each side of the fore-brain (text-fig. 16, *l.h.c.*). On this side the cells have lost almost all traces of their former epithelial character and the spaces are bounded by a thin degenerating layer only a few cells thick; the remaining mesodermal mass, except those parts which are giving rise to the eye muscles, is also breaking down.

Text-figure 14.



Trichosurus vulpecula. G.L. 8·5 mm. ('97).

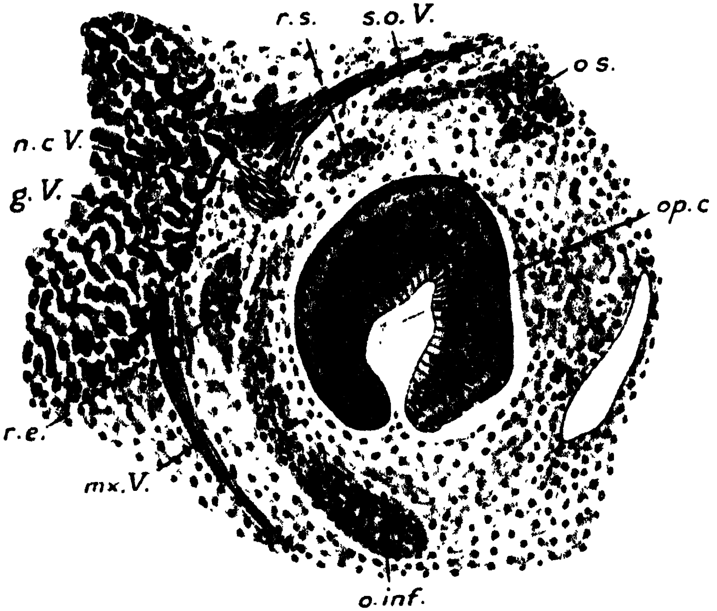
Longitudinal section (S 7-1-8), showing the ciliary ganglion (*cil.g.*), the anterior portion (*r.e.*) of the abducens muscle-mass and the primordium of the m. rectus superior (*r.s.*). × 110.

a.c.a.=arteria cerebri anterior. *g.V.*=Gasserian ganglion. *op.c.*=optic cup. *v.c.a.*=vena cerebralis anterior. *v.c.m.*=vena capitis medialis. *v.o.i.*=vena orbitalis inferior. III.=oculomotor nerve.

The dorso-lateral proliferation is now well marked and its cells are undergoing distinct differentiation to form the future m. rectus superior. It has moved dorsally and anteriorly as compared with the last stage, and now lies medial to the dorsal region of the bulbus (text-figs. 14–16, *r.s.*) and is showing signs of becoming independent.

Further ventrally the cavities have completely disappeared and from the now solid mass of cells the m. obliquus inferior runs outwards and downwards behind the eye (text-fig. 15, *o.inf.*). Immediately medial to the m. obliquus inferior the differentiation of cells destined to become the m. rectus inferior extends downwards, its ventral end turning anteriorly, medial to the bulbus and below the optic stalk.

Text-figure 15.



Trichosurus vulpecula. G.L. 8·5 mm. ('97).

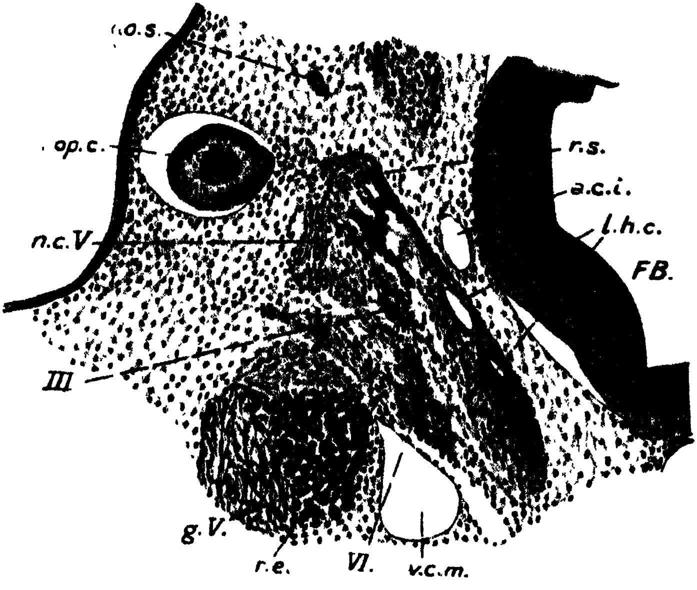
Longitudinal section (S 3 2-8), showing the m. obliquus superior (*o s.*) with its narrow posterior prolongation and the m. obliquus inferior (*o.inf.*) extending below the optic cup (*op.c.*). The distal end of the m. rectus superior (*r.s.*) and the lateral side of the anterior portion (*r.e.*) of the abducens muscle-mass are also seen. × 110.

g.V.=Gasserian ganglion. *n.c.V.*=naso-ciliary branch of V. *s.o.V.*=supra-orbital branch of V. *mx.V.*=maxillary branch of V.

The primordium of the m. obliquus superior is now established as an independent structure. Its main portion forms a condensed mass of cells lying anterior and dorsal to the eye, and from this a narrow prolongation projects posteriorly above the bulbus, the higher pointed end of which comes very close to the m. rectus superior (text-fig. 15, *o.s.*). This backward prolongation is obviously the last remnant of the former connection with the intermediate mass (compare Johnson, '13, p. 150). The last vestiges of the latter can only be recognised in the longitudinal series in front of the Gasserian ganglion and just posterior to the ventral side of the anterior portion of the abducens muscle-mass, with which it is no longer connected; it passes back on the inner side of the root of the maxillary branch of the trigeminal nerve to join with the maxillo-mandibular muscle-mass.

The abducens muscle-mass has not changed in position, except that the posterior dorsal portion does not seem to extend so far backwards, and that the anterior portion has grown out still further laterally (text-figs. 14–16, *r.e.*).

Text-figure 16.



Trichosurus vulpecula. G.L. 8·5 mm. (IV. '01).

Horizontal section through the head (S 7-1-4), showing the last vestiges of the left head-cavity (*l.h.c.*) and the developing m. rectus superior (*r.s.*). The anterior portion (*r.e.*) of the abducens muscle-mass lies in front of the vena capitis medialis (*v.c.m.*) and the Gasserian ganglion (*g.V.*), and in it lies the abducens nerve (VI.). *The ventral edge of the m. obliquus superior* (*o.s.*) is just seen anterior to the optic cup (*op.c.*). × 110 and reduced by ¼.

a.c.i.=arteria cerebri anterior. *FB.*=fore-brain. *n.c.V.*=naso-ciliary branch of the trigeminal nerve. III.=oculomotor nerve.

The oculomotor nerve (text-figs. 14 & 16, III.) again divides at its distal end close to the point of origin of both m. obliquus inferior and m. rectus inferior into many fine fibres, some of which penetrate into the m. obliquus inferior itself (see text-fig. 17, III.).

The ciliary ganglion first appears at this stage as a transversely elongated mass of cells, situated between the ventral end of the anterior portion of the abducens complex and the point of origin of the m. obliquus inferior and the m. rectus inferior (text-fig. 14, *cil.g.*).

The trochlear nerve was observed for the first time in the longitudinal series but it could not be made out in the horizontal. It arises in the usual way from the dorsal side of the brain and runs ventrally almost as far as the level of the dorsal border of the Gasserian ganglion.

The first indication of the formation of muscle cells is seen in series (*b*) and is most marked in the mm. recti superior, inferior and externus, less definite in the m. obliquus inferior, and not recognisable at all in the m. obliquus superior.

Embryos of G.L. 9·5 mm. (V. '01) & 10 mm. (VI. '01) (=Stages X. & XI.). (Pl. I. figs. 1, 2 & text-fig. 17.)

These two embryos, measuring 9·5 and 10 mm. respectively, resemble in many respects those of the last stage but show in some details a slight advance in development.

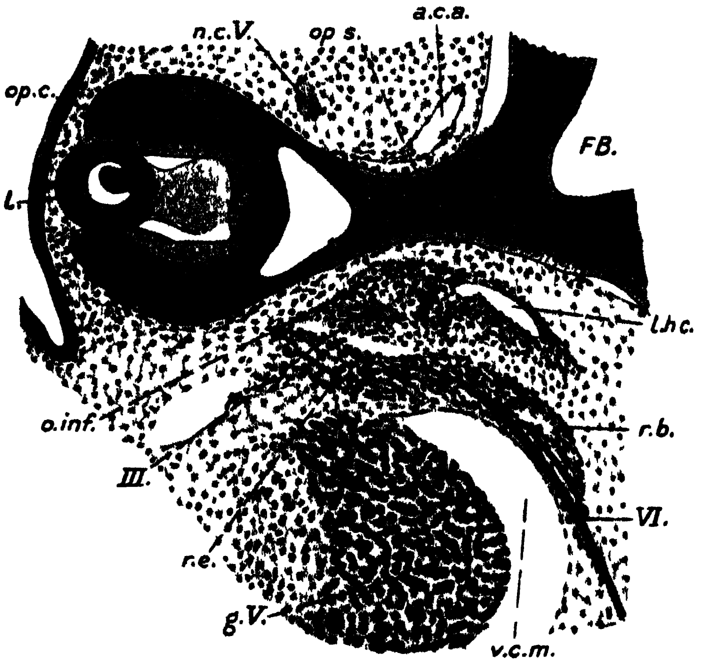
The outline of the eye is more oval and the eyelid has closed over at the extreme ventral side of it. At 10 mm. the cavity of the lens is further reduced and the opening in the optic stalk is narrower.

A slit-like remnant of the head-cavity is still present in both embryos (text-fig. 17, *l.h.c.*). Figs. 1 & 2 (Pl. I.) show posterior and anterior views of a wax-plate model of the embryo of 9·5 mm. The m. rectus superior is now quite conspicuous and has grown forwards and dorsally above the optic cup (figs. 1 & 2, *r.s.*). Below the latter the m. obliquus inferior extends down from the postero-lateral corner of the solid mass of mesoderm which has taken the place of the former head-cavity (fig. 1, *o.inf.*). The m. rectus inferior is now more marked and stretches out anteriorly below the optic stalk (fig. 2, *r.inf.*). The m. obliquus superior (fig. 2, *o.s.*) lies in the same position as in the last stage; but is larger and more prominent and still retains the narrow prolongation running backwards towards the m. rectus superior (fig. 1, *r.s.*). The two portions of the abducens complex are well seen in the model (Pl. I. fig. 1 and text-fig. 17, *r.b.* & *r.e.*) and are very similar to the embryo of 8·5 mm.

At 10 mm. the differentiation of muscle fibres is well established and can be seen in all the developing eye muscles.

In both embryos, at the point of origin of the m. rectus inferior and m. obliquus inferior, a narrow band of mesodermal cells runs directly outwards immediately anterior to the m. obliquus inferior and becomes united with the ventral side of the eyelid posterior to the optic cup (Pl. I. figs. 1 & 2, +).

Text-figure 17.



Trichosurus vulpecula. G.L. 9·5 mm. (V. '01).

Horizontal section through the head (S 4-3-5), passing through the optic cup (*op.c.*), optic stalk (*op.s.*) and lens (*l.*), and showing the last vestige of the left head-cavity (*l.h.c.*) and the proximal end of the m. obliquus inferior (*o.inf.*), into which fibres of the oculomotor nerve (III.) penetrate. The two portions (*r.b.* & *r.e.*) of the abducens muscle-mass are well seen and are penetrated by the abducens nerve (VI.). × 110 and reduced by ¼.

a.c.a.=arteria cerebri anterior. *FB*=fore-brain. *g.V.*=Gasserian ganglion. *n.c.V.*=naso-ciliary branch of the trigeminal nerve. *v.c.m.*=vena capitis medialis.

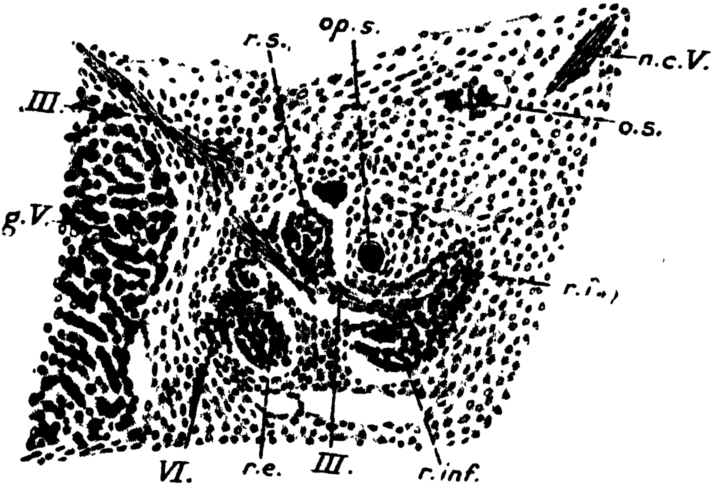
Embryos of G.L. 11 mm., 11·5 mm., & 12 mm. (=Stages XII. & XIII.). (Text-fig. 18.)

The observations were made from six embryos, one of 11 mm. (XII. '04), four of 11·5 mm. (XXII. '04, 5 '97, 9 '98, & VII. '01), and one embryo of 12 mm. (X. '01).

The lumen of the optic stalk is very small and the cavity of the lens is considerably reduced compared with the 10 mm. stage. A thick strand of cells running postero-medially towards the hypophysis on each side of the fore-brain is all that remains of the unused walls of the former head-cavity. With the lateral end of this strand is connected the m. rectus superior which, running dorsally outwards, ends above the eye just behind the middle of the latter (text-fig. 18, *r.s.*).

The m. rectus inferior (text-fig. 18, *r.inf.*) arises below the proximal end of the m. rectus superior with which it is joined by a slender connection; it has increased in thickness and passes out ventrally and anteriorly below the optic stalk. Behind the middle region of this muscle, towards its proximal end, a small new offshoot branches out and stretches up dorsally on to the anterior side of the optic stalk; this is the first appearance of the m. rectus internus (text-fig. 18, *r.i.*).

Text-figure 18.



Trichosurus vulpecula. G.L. 11·5 mm. (5 '97).

Longitudinal section (S 11–3–5), showing the primordium of the m. rectus internus (*r.i.*) which develops as an outgrowth from the m. rectus inferior (*r.inf.*). The m. rectus externus (*r.e.*), m. rectus superior (*r.s.*), and m. obliquus superior (*o.s.*) are also seen. × 110.

g.V. = Gasserian ganglion. *n.c.V.* = naso-ciliary branch of trigeminal nerve.
op.s. = optic stalk. III. = oculomotor nerve. VI. = abducens nerve.

The m. obliquus inferior has changed most in position compared with the last stage. It has moved forwards below the bulbus and now runs antero-ventrally outwards, lying some distance in front of the m. obliquus superior above. It is loosely joined to the outer ventral end of the m. rectus inferior, though this connection is nothing more than a few strands in the 11·5 mm. embryo, and its distal end has begun to turn slightly forwards towards the ali-nasal cartilage from which it finally takes its origin.

The m. obliquus superior is now well developed; it has increased in length and runs from the dorsal anterior side of the bulbus inwards and slightly downwards (text-fig. 18, *o.s.*).

The anterior portion of the abducens muscle-mass (text-fig. 18, *r.e.*), which we may now call the m. rectus externus, stretches out laterally in the usual position posterior to the other muscles and just behind the ciliary ganglion, its pointed lateral end extending outwards towards the posterior border of the eye. The inner dorsal portion of the mass, however, is now shorter and its anterior end, which is united with the m. rectus externus, has thickened, the thickening being the preliminary stage of the later forward movement of this portion which is the primordium of the m. retractor bulbi.

The oculomotor nerve passes ventrally from the mid-brain anterior to the Gasserian ganglion, gives off a twig into the proximal end of the m. rectus superior, then goes downwards through the medial side of the ciliary ganglion immediately behind the optic stalk. Leaving the ganglion, it gives off a branch to the m. rectus inferior and runs outwards on the postero-lateral side of the latter to send an offshoot to the m. obliquus inferior (text-fig. 18, III.). Thus all the oculomotor muscles receive their nerve supply at practically the same time. The ciliary ganglion is slightly larger than at the last stage and forms a transversely elongated mass of cells lying on a level with the optic stalk between the ventral end of the m. rectus externus and the proximal end of the m. rectus inferior.

The trochlear nerve can now be followed from the dorsal surface of the brain downwards immediately in front of the Gasserian ganglion, its distal end turning forwards to run into the m. obliquus superior.

As in the last stage, a strand of mesoderm cells extends laterally from the proximal end of the m. rectus inferior to the ventral border of the eyelid, but here, owing to the forward movement of the m. obliquus inferior below the bulbus, this strand now lies dorsal and posterior to the latter muscle.

The embryo of 12 mm. only differs in the following respects from the 11·5 mm. The eyelids have folded completely over the eye; all the muscles have increased in size and every trace of the walls of the former head-cavity has disappeared. The attachment of the distal end of the m. obliquus inferior to the ali-nasal cartilage has begun and the anterior end of the primordium of the m. retractor bulbi, only apparent as a thickening in the last embryo, now projects slightly forwards towards the optic stalk.

Embryos of G.L. 13 & 13·5 mm. (=Stage XIV.).

The stage consists of three embryos, two measuring 13 mm. (*a*) (IX. '01) & (*b*) (XXV.), and the third (*c*) (XXIV.) with a length of 13·5 mm.

The optic stalk is still hollow, though its cavity is very small and difficult to see in the mid-region of its extent. In (*a*) the eyelids have folded completely over the eye, but in (*b*) they have closed over the lower half only and here the lens is solid. Otherwise the eye resembles that of the last stage.

A vestige of the walls of the former head-cavity is still present in embryo (*a*) only, and is seen as a strand of cells running backwards and inwards from the medial end of the m. rectus superior. In (*a*) the latter is an independent muscle, whereas in (*b*) and (*c*) it is apparently still joined with the m. rectus inferior.

As the positions of the muscles at this stage are very much the same as at 15 mm., of which a wax model has been constructed, they will be described in detail in the sequel. A few remarks may, however, be made here. The m. rectus internus is as yet very short and at 13 mm. the m. rectus inferior is still attached to the m. obliquus inferior, but the separation of the two muscles is complete at 13·5 mm. The m. obliquus inferior is now definitely attached to the ali-nasal cartilage; it has thus changed its position, its outer end turning inwards to the point of attachment, while the proximal end is inserted into the antero-ventral side of the bulbus.

The part of the abducens muscle complex destined to form the m. retractor bulbi has grown still further forwards and outwards towards the medial wall of the eyeball. From its lateral side the m. rectus externus extends almost directly outwards to the posterior lower wall of the bulbus, the two muscles running out at an acute angle to each other, the m. retractor bulbi crossing the inner end of the m. rectus externus.

Embryos of G.L. 14. 14·5, & 15 mm. (=Stage XV.).
(Pl. II. figs. 3 5.)

In this stage we have an embryo of 14 mm. (XXIII.), two pouch young of 14·5 mm., *a* (XV. '02) and *b*, and one of 15 mm., the last three being recently born.

The eyelids are now quite folded over but the optic stalk still contains a minute cavity.

The m. rectus superior (Pl. II. fig. 4, *r.s.*) runs from behind the inner end of the optic stalk just above the proximal end of the m. rectus inferior slightly dorsally and outwards, its pointed outer extremity being inserted in the eyeball dorsal to the posterior side of the latter and at a slightly lower level than the m. obliquus superior.

The m. obliquus superior (Pl. II. fig. 3, *o.s.*) is now a stronger better developed muscle than at 13 mm. It extends directly outwards over the anterior side of the bulbus, its broad inserted end, which is flattened antero-posteriorly, stretching further laterally over the eyeball than any of the other eye muscles.

The m. rectus inferior (Pl. II. figs. 3 & 5, *r.inf.*) arises from below the inner end of the optic stalk and passes downwards and slightly anteriorly below the stalk as a broad muscle which tapers gradually as it proceeds below the bulbus, its pointed ventral end being inserted close to the m. obliquus inferior. Near its wide proximal end, immediately in front of the optic stalk, the m. rectus internus branches off and runs outwards with a slightly dorsal trend on to the anterior side of the bulbus close below the m. obliquus superior (figs. 3 & 5, *r.i.*). The m. rectus internus is as yet a much thinner and shorter muscle than the m. rectus inferior but has nevertheless grown considerably since our last stage, now stretching farther laterally and upwards towards its future point of insertion in the eyeball.

The m. obliquus inferior (Pl. II. figs. 3–5, *o.inf.*) is no longer connected with the m. rectus inferior. It appears as a more or less dorso-ventrally flattened structure of a somewhat oblong shape, having a slightly longer axis in an obliquely antero-posterior direction; as at 13·5 mm., its now proximal but formally distal end is attached to the ali-nasal cartilage, the opposite once proximal end extending towards the lower anterior side of the bulbus.

As regards the abducens complex, we see at 15 mm. very little advance compared with the last stage. The portion corresponding to the m. retractor bulbi (figs. 4 & 5, *r.b.*) stretches farther inwards and posteriorly than any of the other muscles; it increases in thickness as it runs antero-laterally and downwards towards the outer end of the optic stalk, its distal end lying just behind the junction of the oculomotor with the ciliary ganglion. In the model this end shows the first indications of growth round the posterior side of the optic stalk, but this growth round the stalk is, however, more marked in 14 mm. and 14·5 mm. The m. rectus externus (figs. 4 & 5, *r.e.*) stretches from the lateral side of the m. retractor bulbi, not far from the anterior end of the latter, outwards and downwards, its outer pointed end lying below the postero-ventral side of the bulbus some distance behind the outer end of the m. obliquus inferior.

The abducens nerve extends forwards from its origin and then downwards on the outer side of the m. retractor bulbi, running into the abducens complex at the region where the two components of the latter are joined with one another (fig. 4, VI.).

The oculomotor nerve (Pl. II. figs. 3–5, III.) runs forwards medial to the naso-ciliary branch of the trigeminal into the posterior end of the m. rectus superior, and continues obliquely outwards and downwards close against the inner end of the ciliary ganglion and along the side of the m. rectus inferior next the eye. It gives off fibres on this same side into the root of the m. rectus internus. Leaving the m. rectus inferior before the latter reaches the bulbus, it passes anteriorly and ventrally into the m. obliquus inferior.

The ciliary ganglion forms an elongated mass of cells stretching out below the optic stalk; at 15 mm., as seen in the model (fig. 5, *cil.g.*), it is not so elongated as in some of the examples measuring 13 mm. and 14 mm.

The distal end of the trochlear nerve (figs. 3–5, IV.) runs forwards and outwards into the posterior side of the medial end of the m. obliquus superior.

The naso-ciliary branch of the trigeminal nerve (figs. 3–5, V.) passes out immediately lateral to the oculomotor, downwards below the posterior side of the m. rectus superior, and forwards above the optic stalk and along the anterior lower border of the medial end of the m. obliquus superior to the snout.

Fœtus of G.L. 17 and of 17·5 mm.

This stage consists of two pouch young, one measuring 17 mm. and the other 17·5 mm. The optic stalk has quite disappeared and the eye muscles have practically attained their adult positions.

The distal end of the m. obliquus superior turns posteriorly and comes to lie so close to the outer end of the m. rectus superior that the two muscles are inserted almost at the same place.

The m. rectus internus has increased greatly in size and is now a well-developed muscle; it is, however, still connected with the m. rectus inferior at its proximal end by a thin band of cells.

The m. obliquus inferior, as in our last stage, runs obliquely backwards from the ali-nasal cartilage, its posterior end now being inserted anterior to and on the lateral side of the m. rectus externus.

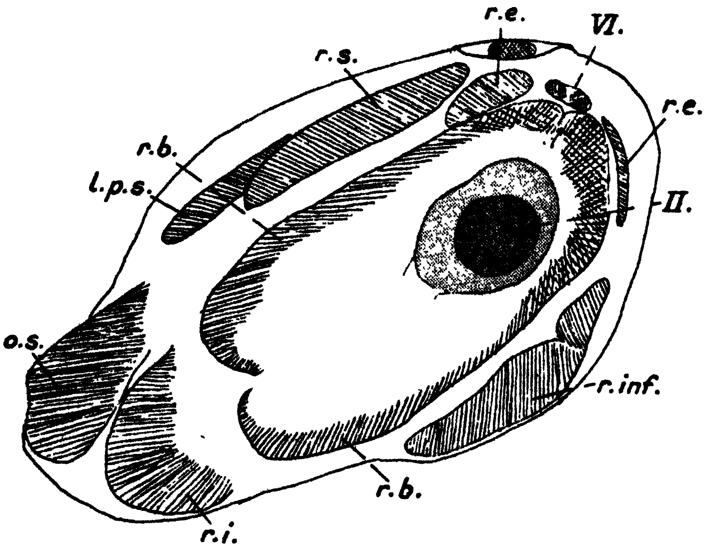
The m. rectus externus and the m. retractor bulbi are now separate muscles. The former is inserted on the posterior side of the bulbus; at about its mid-region on the anterior side, an indentation is present which in all probability represents the first indication of the later division of the muscle into two portions. The m. retractor bulbi has developed considerably; it extends from the middle of the basisphenoid cartilage, to which it is becoming attached, anteriorly and outwards, its distal end surrounding the posterior side of the optic nerve in the shape of a half moon, the pointed ends of which stretch out, the one above, the other below the nerve. The m. retractor bulbi is innervated by a small branch from the abducens nerve before the latter runs into the m. rectus externus.

Fœtus of G.L. 5·2 cm. (Text-fig. 19.)

The m. retractor bulbi (text-fig. 19, *r.b.*) has now attained its adult position. It enters the orbit on the posterior side of the optic nerve and, surrounding the latter, stretches outwards as a circular sheet of muscle gradually diminishing in thickness and increasing in circumference up to its insertion round the inner side of the bulbus within the recti muscles. The two edges of the sheet lie close together, especially at its outer end, but they never completely fuse.

The proximal end of the m. rectus externus (text-fig. 19, *r.e.*) is split up into two portions, already indicated at 17 mm., which unite distally to have a single insertion on the posterior side of the bulbus.

Text-figure 19.



Trichosurus vulpecula. G.L. 5·2 cm.

Longitudinal section (S 23-1-5) passing through the optic nerve (II.) and the surrounding eye muscles. The m. retractor bulbi (*r.b.*) forms a circular sheet of muscle within the other eye muscles. The two portions of the m. rectus externus (*r.e.*) are also seen. × 35.

l.p.s.=levator palpebræ superioris. *o.s.*=m. obliquus superior. VI.=abducens nerve. *r.i.*=m. rectus internus. *r.inf.*=m. rectus inferior. *r.s.*=m. rectus superior.

Summary of Events in Trichosurus vulpecula.

In early stages a large premandibular cavity surrounded by a single epithelial layer of cells is present on each side of the fore-brain posterior to the optic vesicles.

In the 7 mm. embryo an extensive thickening occurs on the lower two-thirds of the posterior wall, later (in the 6 mm. embryo) extending on to the ventral wall of the cavity. From this thickening the m. obliquus inferior and the common primordium of the m. rectus inferior and m. rectus internus develop, the first to appear being the m. obliquus inferior which grows out laterally as a solid protuberance from the ventro-lateral side; the m. rectus inferior arises a little later (in the embryo of 8·5 mm.) as a forward extension from the thickened wall immediately medial and slightly ventral to the m. obliquus inferior.

As development proceeds, the m. obliquus inferior moves forwards below the eye, its distal end turning inwards in the 11·5 mm. embryo to become attached to the ali-nasal cartilage. It becomes independent in the 13·5 mm. embryo and its originally proximal end moves outwards to reach its final insertion on the antero-ventral side of the bulbus. This muscle thus undergoes a noteworthy change in position. The m. rectus inferior grows forwards and outwards, becomes independent and finally extends downwards from below the inner end of the optic cup to become inserted in the ventral side of the bulbus close to the m. obliquus inferior.

From the dorso-lateral region of the cavity in the 6 mm. embryo appears a bud-like outgrowth whose surrounding walls, especially that of the posterior side, proliferate and give rise to the m. rectus superior. The primordium of this muscle grows antero-posteriorly over the eyeball, becomes independent and very early attains its final position (11 to 12 mm.).

The remaining walls of the head-cavity undergo degeneration and become obliterated in the surrounding mesenchyme.

The m. rectus internus is the last of the eye muscles to make its appearance. It first develops in the 11 mm. embryo as an outgrowth from near the proximal end of the m. rectus inferior and grows dorso-laterally to become inserted on the anterior side of the bulbus.

The abducens complex is first seen as a solid mass of cells lying posterior to the premandibular cavity and consisting of postero-dorsal and antero-ventral portions. The latter grows out laterally as the m. rectus externus and the former grows forwards and outwards, crossing the inner end of the m. rectus externus, its distal end finally surrounding the optic nerve as the m. retractor bulbi. The m. retractor bulbi is the last of the eye-muscles to assume its final position.

The m. obliquus superior takes its origin from a mass of cells, termed by me the intermediate mass, which can be traced downwards into continuity with the maxillo-mandibular mass of mesenchyme. The anterior band-like part of the intermediate mass separates off to form the primordium of the m. obliquus superior. It grows inwards to form a muscular band, which extends out from above the m. rectus internus to the anterior side of the bulbus.

The more posterior portion of the intermediate mass, attached to the maxillo-mandibular mesenchyme, is wider and composed of more loosely arranged cells, and is also connected in our earlier stages with the lateral side of the primordium of the m. rectus externus and for a still shorter period with the postero-lateral wall of the head-cavity. After the m. rectus externus and the m. obliquus superior become independent the intermediate mass disappears.

NOTES ON OTHER MARSUPIALS.

Phascolarctos cinereus. Embryo of G.L. 4 mm.

Our earliest stage of *Phascolarctos cinereus* measures 4 mm. at its greatest length. The outer wall of the optic vesicle is thickened and flattened and the optic stalk is in wide communication with the fore-brain.

Situated postero-medially to the optic vesicle on each side is a large premandibular head-cavity, the long axis of which lies in the sections in an obliquely antero-posterior direction. From the posterior and postero-lateral walls active proliferation is taking place by means of hollow buds which are growing out from the cavity, a solid mass of cells being formed by the thickened walls of one bud running into those of another. Next the fore-brain the walls consist of a single epithelial layer, which in some places, however, is not distinctly seen.

Unfortunately, this embryo is not well preserved and the abducens muscle-mass is very difficult to distinguish from the thickened posterior wall of the head-cavity.

Embryo of G.L. 7·5 mm. (Text-fig. 20.)

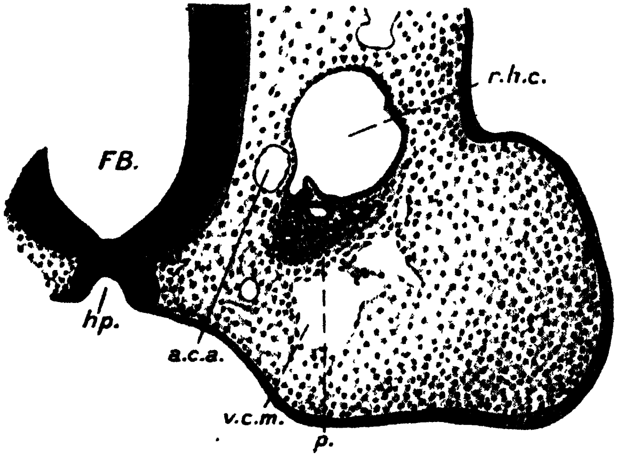
An older embryo, measuring 7·5 mm., shows the optic vesicle much further invaginated and the primordium of the lens in the form of a thickened hollow ingrowth from the ectoderm.

The head-cavity has increased considerably in size, having a maximum diameter of ·30 mm. × ·26 mm. (text-fig. 20, *r.h.c.*), and its antero-ventral portion has grown forwards above the optic vesicle. The whole of the posterior wall is thickened; hollow buds, many of which are long and tubular, run out into a mass of closely packed cells, the entire region appearing as an irregular mass pitted with small hollow spaces (text-fig. 20, *p.*). The wall next the fore-brain, as in our first stage, is composed of a single layer of cells.

The abducens muscle-mass, which is clearly recognisable, consists of a narrow postero-dorsal portion lying along the medial side of the vena capitis medialis; this continues into the larger anterior part, which extends obliquely forwards and downwards postero-laterally to the head-cavity to meet the intermediate mass. The latter stretches forwards just above the optic vesicle into a bulbous extension, the primordium of the m. obliquus superior, and runs downwards into the maxillo-mandibular mesenchyme; it is also connected with the postero-lateral wall of the head-cavity.

The oculomotor nerve is well developed, its distal end terminating some distance from the head-cavity.

Text-figure 20.



Phascolarctos cinereus. G.L. 7·5 mm.

Horizontal section through the head (S 5-3 7), passing immediately above the optic vesicle and just below the middle of the right head-cavity (*r.h.c.*) The posterior wall of the cavity is actively proliferating (*p*). Size of cavity ·30 mm. × ·26 mm. × 110 and reduced by ¼.

a.c.a. = arteria cerebri anterior. *FB.* = Fore-brain. *hp.* = hypophysis.

Embryo of G.L. 9 mm. (Text-fig. 21.)

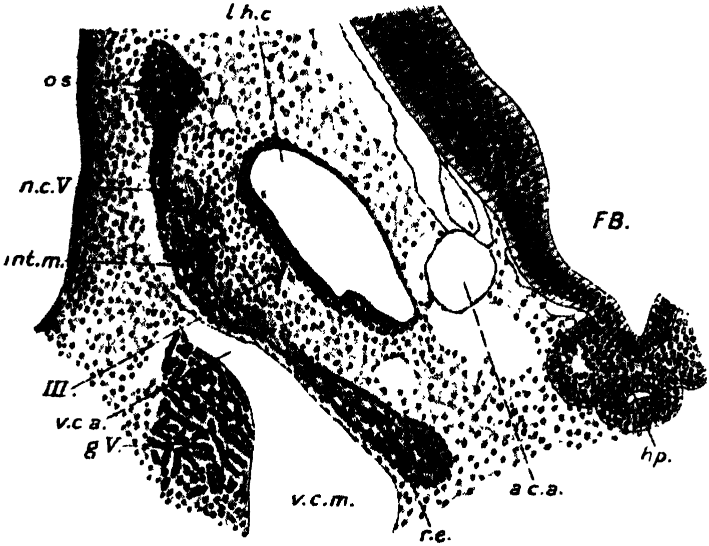
At 9 mm. the optic vesicle is closed except on the medial side where the hollow optic stalk runs inwards to the fore-brain. The lens has now the form of a vesicle and is no longer connected with the ectoderm.

The head-cavity is still larger (text-fig. 21, *l.h.c.*) and resembles in shape that of *Trichosurus*, embryo (*a*) 7·25 mm. A large bud is present on the dorso-lateral side, the posterior and ventral walls of which are thickened, whilst the whole of the postero-lateral wall of the cavity is actively proliferating.

The primordium of the m. obliquus inferior runs out from the postero-lateral side of the cavity behind the optic vesicle, and medial to this muscle there is an indication of the future m. rectus inferior.

The abducens muscle complex is well marked in this embryo, and its connection with the intermediate mass and the m. obliquus superior is clearer than in any of the embryos of *Trichosurus* examined (text-fig. 21). The abducens nerve runs into the postero-dorsal portion which is situated in its usual position medial to the vena capitis medialis; the anterior portion (text-fig. 21, *r.e.*) lies along the postero-lateral side of the cavity in front of the vena capitis medialis and stretches laterally into the intermediate mass (text-fig. 21, *int.m.*). The latter extends, on the one hand, forwards and upwards to be connected by a narrow band of cells with the m. obliquus superior (text-fig. 21, *o.s.*) and on the other, downwards and backwards to join the maxillo-mandibular mesenchyme.

Text-figure 21.



Phascolarctos cinereus. G.L. 9 mm.

Horizontal section through the head (S 4-2-6) passing through the left head-cavity (*l.h.c.*), about a quarter of the way down, and showing the m. obliquus superior (*o.s.*) growing forwards from the intermediate mass (*int.m.*), this being also united with the abducens muscle-mass (*r.c.*). In the next few sections further ventrally, the intermediate mass is joined with the postero-lateral wall of the head-cavity at approximately the region marked *. ×110 and reduced by $\frac{1}{3}$.

a.c a.=arteria cerebri anterior. *FB.*=fore-brain. *g.V.*=Gasserian ganglion. *hp.* = hypophysis. *n.c.V.* = naso-ciliary branch of the trigeminal nerve. *v.c a.*=vena cerebralis anterior. *v.c.m.*=vena capitis medialis. III.=oculomotor nerve.

The m. obliquus superior is a compact mass of cells lying antero-laterally to the cavity above the optic cup. The intermediate mass a few sections below the level of text-fig. 21 is attached to the extreme postero-lateral wall of the cavity.

The oculomotor nerve runs down close to the postero-lateral wall of the premandibular cavity (text-fig. 21, III.) and below the level of the same splits up into many fibres near the point of origin of the m. obliquus inferior.

Embryo of G.L. 11 mm.

In our next embryo, which measures 11 mm., all traces of the head-cavity have disappeared, the m. obliquus inferior has begun to move forwards below the eye and the m. rectus inferior is further developed. *Phascolarctos* has now reached a stage in development intermediate between that of the *Trichosurus* embryos of 10 and 11 mm.

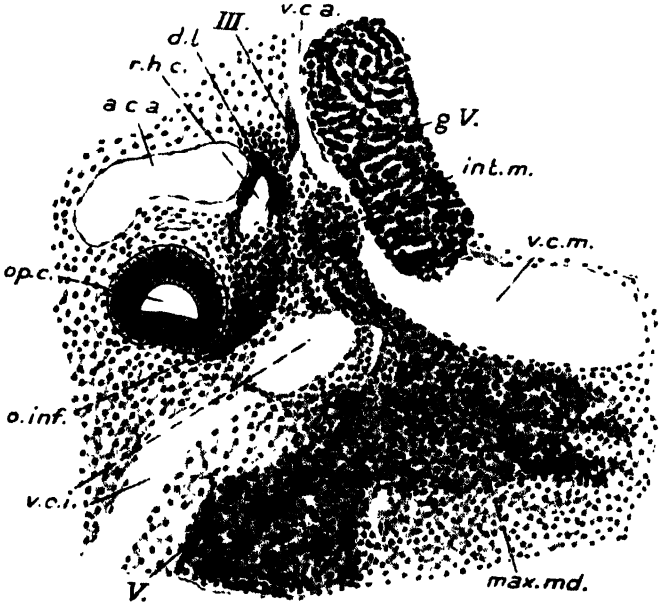
The later history of the eye muscles is similar to that of *Trichosurus* and need not again be described.

PHASCOLOMYS MITCHELLI. (Text-fig. 22.)

The two youngest embryos of *Phascolomys mitchelli* measure at their greatest length 9 mm. and 8·5 mm. respectively; the former is slightly the younger of the two.

The optic vesicle is closed and the optic stalk is in wide communication with the fore-brain; the lens is a hollow vesicle shut off from the ectoderm.

Text-figure 22.



Phascolomys mitchelli. G.L. 8·5 mm.

Longitudinal section (S 2-1-1) passing through the lateral side of the right head-cavity (*r.h.c.*) and showing the proliferation from the dorso-lateral wall (*d.l.*) and the primordium of the m. obliquus inferior (*o.inf.*). The intermediate mass (*int.m.*) situated between the cavity and the Gasserian ganglion (*g.V.*) is seen to be connected with the maxillo-mandibular mesenchyme (*max.md.*) by a band of cells lying just on the medial side of the vena orbitalis inferior (*v.o.i.*). ×110 and reduced by ¼.

a.c.a.=arteria cerebri anterior. *op.c.*=optic cup. *v.c.a.*=vena cerebralis anterior. *v.c.m.* =vena capitis medialis. *v.o.i.*=vena orbitalis inferior. III.=oculomotor nerve.

In the 9 mm. embryo the head-cavity is large and triangular in shape, resembling that of the 9 mm. stage of *Phascolarctos*, while in the 8·5 mm. specimen it is much reduced in size (text-fig. 22, *r.h.c.*). In both embryos a dorso-lateral proliferating muscle-bud is present (text-fig. 22, *d.l.*), and the m. obliquus inferior extends down from the ventro-lateral wall posterior and ventral to the optic cup (text-fig. 22, *o.inf.*).

The anterior portion of the abducens muscle complex is joined with the intermediate mass, and the connection of the latter with the maxillo-mandibular mesenchyme by means of a wide band of cells is well seen in the 8·5 mm. embryo (longitudinal series) (text-fig. 22).

The m. obliquus superior has the same appearance as in the 9 mm. stage of *Phascolarctos*; on its inner border it practically surrounds the supra-orbital branch of the trigeminal nerve.

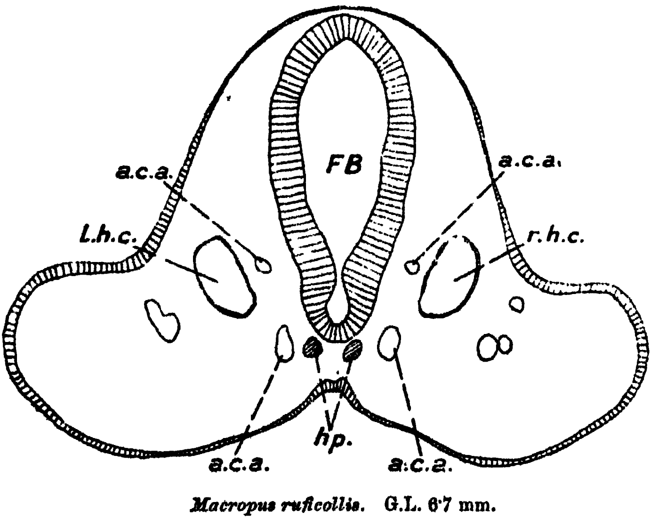
The oculomotor nerve is prolonged ventrally into the m. obliquus inferior and the abducens nerve runs into the hinder end of the postero-dorsal portion of the abducens muscle complex.

The examination of the two older stages, measuring 15·5 mm. and 17·5 mm. respectively, shows that the further development of the eye muscles proceeds as in *Trichosurus*.

MACROPUS RUFICOLLIS. (Text-figs. 23 & 24.)

Only one embryo of *Macropus ruficollis*, with a maximum length of 6·7 mm., came under observation. The optic vesicle is

Text-figure 23.



Macropus ruficollis. G.L. 6·7 mm.

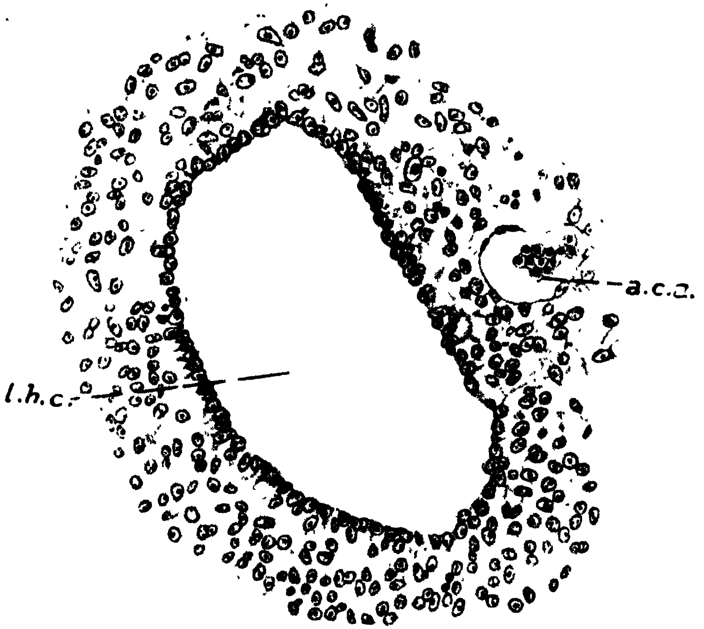
Horizontal section through the head (S 4-2-1) showing the head-cavity on each side (*l.h.c.* & *r.h.c.*). Size of cavities: left = ·29 mm.×·14 mm.; right = ·30 mm.×·16 mm. ×50 and reduced by ½.

a.c.a. = arteria cerebri anterior. *FB.* = fore-brain. *hp.* = hypophysis.

flattened, its outer layer being much thickened and bulging into the cavity, and the wide opening in the optic stalk is connected with the fore-brain. The ectoderm opposite the vesicle is as yet only slightly thickened on the ventro-lateral side of the latter.

This embryo possesses a large premandibular head-cavity on each side of the fore-brain in the usual position medial and posterior to the optic vesicle (text-figs. 23 & 24, *l.h.c.* & *r.h.c.*). The dorsal portion of the cavity is somewhat irregular in shape with a small area marked off towards the median plane by a constriction as in *Trichosurus*, embryo (*a*), 5 mm.; further ventrally, it assumes a more oval form (text-figs. 23 & 24, *l.h.c.* & *r.h.c.*), measuring on the left side ·29 mm. × ·29 mm. × ·14 mm. and on the right ·31 mm. × ·30 mm. × ·16 mm., the shortest measurement being the transverse one. It is lined throughout by a single layer of epithelial cells.

Text-figure 24.



Macropus ruficollis. G.L. 6·7 mm.

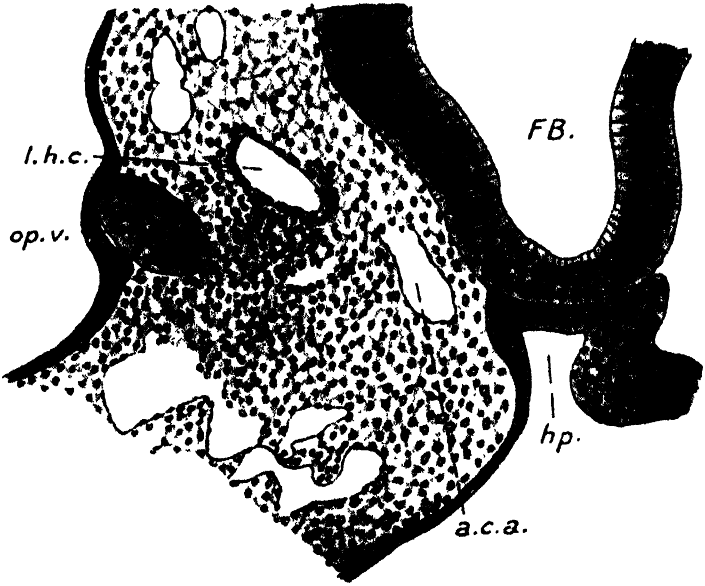
Left head-cavity (*l.h.c.*) showing its lining of a single layer of epithelial cells. Size of cavity = ·29 mm. × ·14 mm. × 200.

The abducens muscle complex, the intermediate mass and the primordium of the m. obliquus superior are united in the usual way, but their respective limits are difficult to determine as their component cells are loosely connected and rather spread out, so that they are not easily distinguished from the surrounding mesenchyme. The primordium of the m. obliquus superior is more compact than the rest and forms a large rounded mass above the optic vesicle, posterior to and on the outer side of the supra-orbital branch of the trigeminal nerve.

PERAMELES spp. (Text-fig. 25.)

Our first stage of *Perameles* is an embryo of *P. nasuta* measuring 5·7 mm. at its greatest length. The primary optic vesicle is flattened and the outer layer thickened, and the optic stalk contains a wide cavity communicating with the fore-brain. The adjacent ectoderm is enlarged and slightly invaginated to form the primordium of the lens.

Text-figure 25.



Perameles nasuta. G.L. 5·7 mm.

Horizontal section through the head (S 4–1–11), showing the left head-cavity (*l.h.c.*) when at its largest. × 110.

a.c.a. = arteria cerebri anterior. *FB.* = fore-brain. *hp.* = hypophysis. *op.v.* = optic cup.

A small very reduced head-cavity is to be seen on each side posterior and medial to the optic vesicle (text-fig. 25, *l.h.c.*). It is very irregular in form, is much broken up, and for the most part is bordered simply by mesenchyme cells, a definite layer of epithelium having been observed only in the section figured where the cavity is larger than it is elsewhere. There appear to be proliferations of cells round parts of the cavity but no definite muscle-masses can be distinguished.

The m. obliquus superior and the abducens muscle-mass are connected by means of the intermediate mass and show the same relations as described for other genera. A portion of the intermediate mass is apparently joined with a side of the head-cavity but the limits between the parts are again difficult to make out.

In the next embryo, which measures 7 mm., the cavity of the optic vesicle is almost closed and the lens forms a hollow vesicle but the optic stalk is still widely open. Small head-cavities are again found, the one on the left side being larger and better developed than in the 5·7 mm. embryo, while that on the right is more or less broken up. On both sides a thickening is present on the postero-lateral side of the head-cavity and the primordium of the m. obliqnus inferior extends down below the cavity; on the left a proliferating dorso-lateral bud is present.

In the 8·75 mm. embryo of *P. obesula* the cavities have almost disappeared and may be compared with the traces of the head-cavity still left in the 8·5 mm. embryo of *Trichosurus*. The muscles are developing as in the latter.

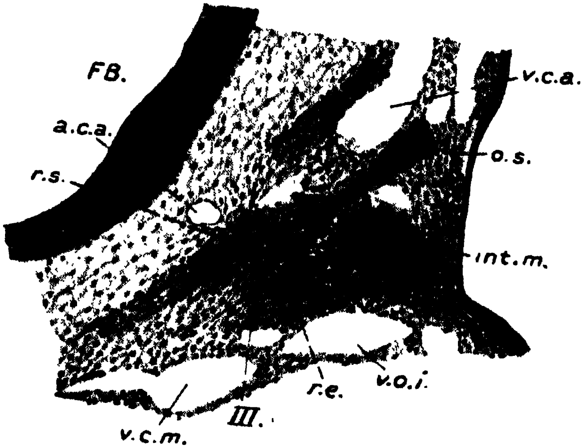
DIDELPHYS MARSUPIALIS. (Text-fig. 26.)

We had at our disposal only one embryo of *Didelphys* measuring 8·5 mm. The optic vesicle is completely invaginated and its cavity obliterated; the optic stalk on the right side contains a prominent cavity connecting it with the fore-brain but on the left it is almost solid, only a few very small hollow spaces remaining, and these are chiefly on the side next the brain. On the left side the lens has just separated off from the ectoderm but lies close to the latter and is of a remarkably small size, but on the right no lens could be seen and had apparently not yet begun to develop.

No head-cavities are present but in the usual position of the latter, posterior and dorsal to the eye, lies a condensed mass of mesenchyme cells from which the eye muscles are developing.

On careful examination, the postero-lateral side of this mass, which extends obliquely forwards in front of the vena capitis medialis, is recognised without difficulty as the abducens muscle-mass (text-fig. 26, *r.e.*); lying parallel to this, on the anterior side of the whole group of cells, we see the future m. rectus superior (text-fig. 26, *r.s.*), between the medial side of which and the abducens muscle-mass runs down the oculomotor nerve. The lateral side of the abducens muscle-mass is joined with the intermediate mass which, stretching forwards above the eye, is continued into an outgrowth corresponding to the primordium of the m. obliquus superior (text-fig. 26, *o.s.* and *int.m.*). The intermediate mass is also united with the lateral side of the primordium of the m. rectus superior, thus recalling the connection of the intermediate mass with the postero-lateral wall of the head-cavity in other marsupials. The central region of the cell group is compact and as one passes further ventrally, below the section figured, the primordium of the m. obliquus inferior is seen to grow out downwards from this region, its approximate position being marked in the diagram by a broken circle (text-fig. 26). In still younger embryos it is possible that vestiges of a cavity may be present, but if so they become early obliterated.

Text figure 26.



Didelphys marsupialis. G.L. 8·5 mm.

Horizontal section through the head (S 2-4-11), showing the mass of mesenchyme dorsal to the optic cup, from which the eye muscles are developing. The broken circle indicates approximately the area from which, further ventrally, the primordium of m. rectus inferior grows out. × 100 and reduced by ¼.

a.c.a. = arteria cerebri anterior. *FB.* = fore-brain. *int.m.* = intermediate mass. *o.s.* = m. obliquus superior. *r.e.* = anterior portion of abducens muscle-mass. *r.s.* = m. rectus superior. *v.c.a.* = vena cerebralis anterior. *v.c.m.* = vena capitis medialis. *v.o.i.* = vena orbitalis inferior. III. = oculomotor nerve.

The conditions in *Didelphys* are interesting, as they may possibly form a clue to the more accurate identification of the group of mesenchyme cells from which the eye muscles arise in higher mammals. Reuter ('97), as already mentioned, regards the eye muscles in the pig as originating from a single mass of mesenchyme cells. In the description of his earliest stage (G.L. 10 mm.) he says (p. 384):—"Sie [die allererste Anlage der Augenmuskeln] hat die Form einer gestielten Sichel und umgreift mit den beiden nach vorn gerichteten Schenkeln den Augenstiel, während der dritte hintere Schenkel vom N. abducens fortgesetzt wird. Die Spitze des oberen Schenkels bildet sich mit ihrem Nerven, dem N. trochlearis, am spätesten aus." By the second stage (G.L. 13 mm.):—"Die Muskulaturanlage wandert nach vorn gegen den N. opticus hin und verliert ihren hinteren Schenkel, welcher von der Vena jugularis nach vorn zusammengedrängt wird." It will be remembered that in *Trichosurus* (G.L. 7 mm.) the root of the vena cerebralis anterior penetrates through the dorsal side of the larger anterior portion of the abducens muscle-mass; this does not occur in the specimen of *Didelphys* which has perhaps passed this stage in development.

DASYURUS VIVERRINUS.

A good series of embryos of *Dasyurus viverrinus* was examined and no signs of any head-cavities were observed. The small size of these embryos, however, makes it exceedingly difficult to identify any small vestiges of cavities which might possibly persist.

We may conclude from the preceding facts that the occurrence of well-developed premandibular head-cavities is characteristic of the Diprotodontia, large cavities being found in *Trichosurus*, *Phascolarctos*, *Phascolomys* and *Macropus*. In the Polyprotodontia, on the other hand, cavities may be present, as for example in *Perameles*, but only in the form of comparatively small irregular spaces, quite insignificant as compared with those in the former group, or they are altogether absent, as in *Dasyurus* and probably also in *Didelphys*, the muscles from the first somite then developing from a solid mesodermal mass as in higher mammals.

Although there are variations in the mode of proliferation from the walls of the premandibular cavity in the different genera, the later development of the eye muscles presents much similarity and *Trichosurus* may be regarded as typical.

CONCLUDING REMARKS.

From the foregoing observations we have further evidence of the unique position occupied by the marsupials in the Class Mammalia. The possession of well-developed premandibular head-cavities, as yet observed in no other mammals, recalls the conditions existing in many reptiles. These cavities correspond very closely with those found in the lizard (Corning, '**99**), in the snake (Oppel, '**90**) and in the Chelonia (Filatoff, '**07** & Johnson, '**13**).

Owing to lack of material of early stages it has not been possible to determine the exact mode of origin of the cavities at the anterior end of the head in marsupials, or even to establish the existence of a median piece connecting the two across the middle line. The connecting piece in reptiles very often forms a wide cross-canal, which may persist until a comparatively late stage or may disappear before the cavities have attained their maximum size. This variation is mentioned by Corning ('**00**) (p. 66):—"Aus den Oppel'schen Figuren, wie aus den meinigen, geht hervor, wie stark die Variationen sind, welche man in Bezug auf die Ausbildung des mittleren Verbindungsstückes zwischen den beiden Kopfhöhlen antrifft. Nicht selten bleibt die Verbindung noch in relativ später Zeit bestehen, in anderen Fällen is sie schon zu einer Zeit verschwunden, wo die Höhlenbildung im lateralen Theile noch nicht auf ihrem Höhepunkt angelangt ist, in noch anderen sehen wir im Stiel einzelne kleinere Höhlenbildungen auftreten, die sich später mehr oder weniger vollständig zu einer grossen Höhle vereinigen."

In the 5 mm. embryo of *Trichosurus* and in the 6·7 mm. *Macropus*, the small median portion partially constricted off from the rest of the cavity (text-fig. 1, *n.*) may possibly coincide with the swollen part of the stalk, which runs from the somite to the middle line in *Anguis fragilis* (called by Oppel the "Hals") and which takes a part in the formation of the head-cavity.

We have seen that the walls of the premandibular cavity, as in most other Vertebrates, give rise to the muscles innervated by the oculomotor nerve. In *Trichosurus* and probably also in *Phascolomys*, the primordium of the m. obliquus inferior and the common primordium of the mm. rectus inferior and rectus internus develop as solid outgrowths from the posterior and ventral walls, whilst the primordium of the m. rectus superior arises from the walls of a hollow evagination on the dorso-lateral side, the latter mode of origin resembling that of all the oculomotor muscles in *Lacerta* (Corning, '**99**). In *Phascolarctos*, elongated hollow outgrowths occur along the greater part of the posterior wall of the cavity, an extensive budding here taking place. The further development of these three muscles in the marsupials agrees very closely with that of the same muscles in *Chelydra* (Johnson, '**13**).

The m. rectus internus and the m. rectus inferior develop from a common primordium, the m. rectus internus first appearing as an offshoot from near the proximal end of the m. rectus inferior; this offshoot grows directly upwards and outwards to the anterior side of the bulbus. In *Chelydra*, according to Johnson ('**13**), the common primordium becomes transformed into "a solid elongate mass. By the 11 mm. stage a constriction has appeared, slightly beyond the middle of this mass, differentiating it into a proximal M. rectus inferior and a distal M. rectus medialis. .... The proximal end, which at first is continuous with the distal end of the M. rectus inferior, works up along the medial side of this muscle so that the final separation of the two takes place at their proximal ends, *i. e.* their ends of origin." No movement of this kind has been observed in *Trichosurus*, and if it occurs it must take place in the short interval between the 10 mm. and 11 mm. stages.

The abducens complex and the m. obliquus superior are difficult to identify in our earliest stages, but by comparison with slightly older embryos it is possible to make out their contours in the surrounding mesenchyme from which they are not easily distinguished. In our first stages, up to 8·5 mm., the primordia of both these muscles are united with the maxillo-mandibular mesenchyme by an intermediate mass of more loosely connected cells, the position of which is well seen in *Phascolomys* (text-fig. 21, p. 332). The m. obliquus superior arises from this intermediate mass as an upgrowth which extends forwards above the eye, the intermediate mass itself apparently degenerating. In the rabbit, Edgeworth (**'03**) regards the m. obliquus superior and the m. rectus externus as "specialised portions of the mandibular and hyoid myotomes which separate, the former late, the latter very early in development, from the upper ends of their respective myotomes" (p. 82). In *Chelydra*, according to Johnson (**'13**), the m. obliquus superior (p. 159) "grows forward as a stream of cells from the dorsal portion of the mesenchymal cell-mass which results from the second head somite," the ventral portion of the latter at the 5 mm. stage being in close contact with the mesoderm of the mandibular arch. If we compare these conditions with those in *Trichosurus*, *Phascolarctos* and *Phascolomys*, we may conclude with some probability that the intermediate mass answers to the second somite of the head whose cavity is already obliterated, or in which a cavity has never developed, and from whose dorsal region the m. obliquus superior takes its origin. In *Chelydra* also, at a certain stage in development, the identification of the second somite is a matter of some difficulty. In the embryo of 7 mm. Johnson says (p. 142):—"The second head somite of the 7 mm. stage is of such indistinct and indefinite form that it may easily escape notice. It reaches here the most obscure phase of its development. The more or less conspicuous cavities of earlier stages have collapsed and broken down, and with their disappearance the cells of their walls are with difficulty distinguished from the intruding and intermingling mesenchymal elements."

No cavity is seen in the abducens muscle-mass, which in our earliest embryo is quite solid and shows a temporary attachment, as above mentioned, to the intermediate mass, this connection being probably a secondary phenomenon as in *Chelydra*, where it also occurs. It is possible that the intermediate mass, *i. e.* the second somite, may contribute towards the formation of the m. rectus externus as in some fishes (Dohrn, **'04**, Neal, **'14**), but we have no direct evidence of this in *Trichosurus*. The m. rectus externus and m. retractor bulbi develop exactly as in *Chelydra*; the origin of the m. retractor bulbi bearing no resemblance to that of the pig where, according to Reuter (**'97**), p. 376:— "Dieser Muskel ensteht aus dem inneren Mantel des Augenmuskelkelches durch Abspaltung von vorn nach hinten."

In *Chelydra*, however, the m. retractor bulbi separates off from the m. rectus externus at an early stage before the second somite has completely degenerated and when the m. rectus inferior and internus first begin to differentiate from each other, whereas in *Trichosurus* it only becomes an independent muscle at 17·5 mm. after the other muscles of the eye have assumed their final positions and at a time when the m. rectus inferior and internus are almost completely separated. The m. retractor bulbi in both animals is the last of the eye-muscles to reach its adult position.

The cranial nerves III, IV and VI arise from the brain and grow towards their respective muscles, their connection with the mesodermal somites being a secondary one as shown by Neal (**'14**). No independent origins in the muscles themselves are present as described by Filatoff (**'07**) in *Emys lutaria*. The oculomotor runs at its distal end into the proliferation on the postero-lateral wall of the head-cavity and breaks up into many fibres at the region where the m. obliquus inferior and m. rectus inferior first grow out, these two muscles being innervated at practically the same time; later, at the earliest indication of the m. rectus internus, fibres are seen to run into the root of the latter. The abducens develops in the typical manner and runs into the posterior end of the abducens muscle-mass; when the m. retractor bulbi grows forwards and separates off from the m. rectus externus, the nerve branches into the two muscles at the point where the former crosses the medial side of the latter. The trochlear, as is usually the case, arises later than the other two nerves. In *Trichosurus* it first appears at 8·5 mm. and does not reach the m. obliquus superior until 11 mm., when it penetrates into the posterior side of the medial end of this muscle.

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EXPLANATION OF THE PLATES.

Lettering.

aln. = ali-nasal cartilage.
cil.g. = ciliary ganglion.
FB. = fore-brain.
e. = eyeball.
l. = lens.
n.c.V. = naso-ciliary branch of the trigeminal nerve.
o.inf. = m. obliquus inferior.
op.c. = optic cup.
op.s. = optic-stalk.
o.s. = m. obliquus superior.
r.b. = m. retractor bulbi.
r.e. = m. rectus externus.
r.i. = m. rectus internus.
r.inf. = m. rectus inferior.
r.s. = m. rectus superior.
III. = oculomotor nerve.
IV. = trochlear nerve.
V. = trigeminal nerve.
VI. = abducens nerve.
+ = band of mesodermal cells.

Plate I.

Trichosurus vulpecula. G.L. 9·5 mm. (V. '01).

Fig. 1. Coloured drawing of wax-plate model, posterior view, showing the anterior (*r.e.*), and the posterior (*r.b.*) portions of the abducens muscle-mass, the primordium of the m. obliquus inferior (*o.inf.*) extending down from the postero-lateral corner of the solid mass of mesoderm representing the former head-cavity. The primordium of the m. rectus superior (*r.s.*) stretches up above the optic cup from the dorso-lateral side of the same mass. Nerve III. (III.) runs down just in front of the abducens muscle complex and into the hinder end of the latter runs Nerve VI. (VI.) A band of mesodermal cells (+) is seen to extend out towards the ventral border of the eyelid. × 300 and reduced by $\frac{1}{3}$.

2. Anterior view, showing the primordium of the m. obliquus superior (*o.s.*) with its narrow prolongation lying anteriorly to the optic cup (*op.c.*), the primordium of the m. rectus inferior (*r.inf.*), extending forwards below the optic stalk from the medial side of the m. obliquus inferior (*o.inf.*). The primordium of the m. rectus superior (*r.s.*) is again seen. The naso-ciliary branch (V.) of Nerve V. runs forwards below the m. obliquus superior. *l*=lens. The band of mesodermal cells (+) extending out to the ventral border of the eyelid is again seen. × 300 and reduced by $\frac{1}{3}$.

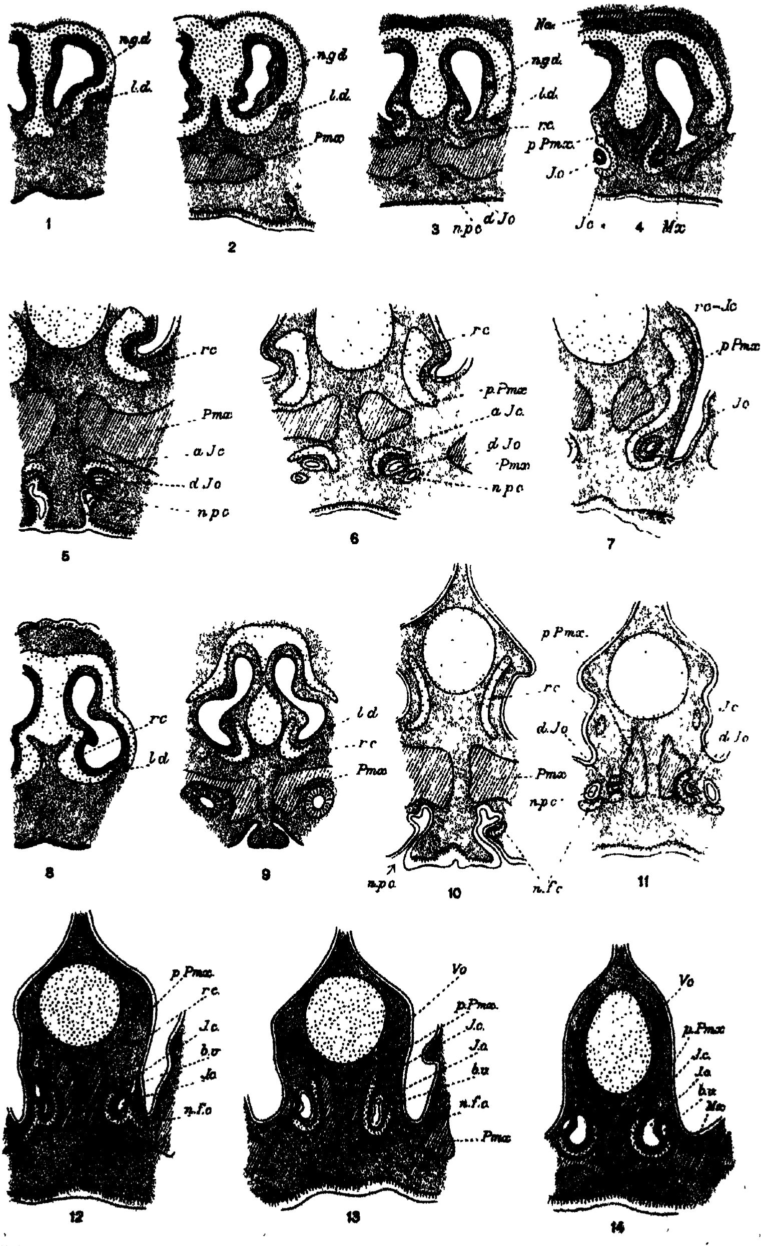
Plate II.

Trichosurus vulpecula. G.L. 15 mm.

Fig. 3. Coloured drawing of wax-plate model, anterior view, showing the m. obliquus superior (*o.s.*), the m. obliquus inferior (*o.inf.*), and the m. rectus inferior (*r.inf.*) from which branches out the m. rectus internus (*r.i.*). Nerve IV. (IV.) runs into the postero-medial side of the m. obliquus superior (*o.s.*). × 150 and reduced by approximately $\frac{2}{5}$.

4. Posterior view, showing the m. rectus superior (*r.s.*), the m. retractor bulbi (*r.b.*) still connected with the m. rectus externus (*r.e.*), and the m. obliquus inferior (*o.inf.*) in which runs Nerve III. Nerve VI. is seen at the point of union of the m. rectus externus and the m. retractor bulbi. A faint dotted line indicates approximately the line of junction between the m. rectus externus and the m. retractor bulbi. × 150 and reduced by approximately $\frac{2}{5}$.

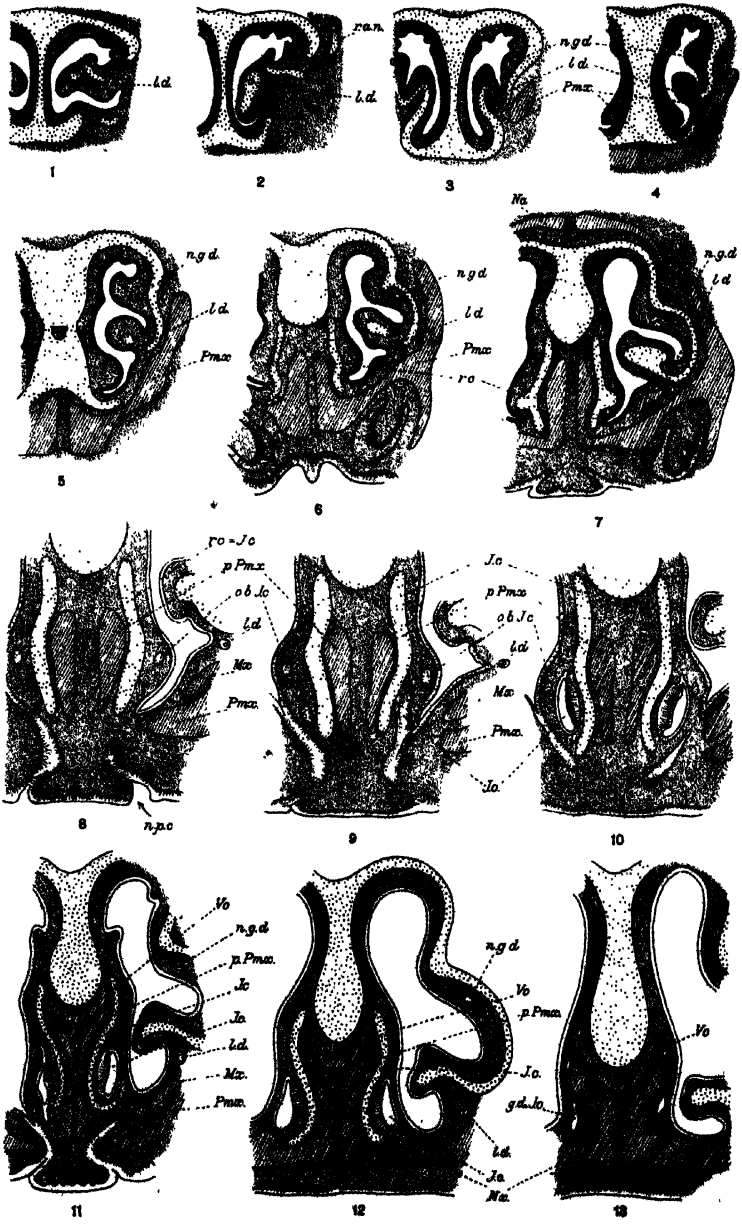
5. Ventral view, showing the distal end of the m. retractor bulbi (*r.b.*) which is growing forwards round the optic stalk, the m. obliquus inferior (*o.inf.*) attached to the ali-nasal cartilage (*aln.*), and the ciliary ganglion (*cil.g.*) lying below the optic stalk. Nerve III. is seen to run out from the m. rectus inferior (*r.inf.*) into the m. obliquus inferior. × 150 and reduced by approximately $\frac{2}{5}$.



R.B. del.

Cambridge University Press.

ORGAN OF JACOBSON IN TALPA AND CENTETES.



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ORGAN OF JACOBSON IN CHRYSOCHLORIS.

25. On the Organ of Jacobson and its Relations in the "Insectivora."—Part II. *Talpa*, *Centetes*, and *Chrysochloris*.

By Lieut. R. Broom, M.D., D.Sc., C.M.Z.S., R.A.M.C.

[Received April 27, 1915: Read May 11, 1915.]

(Plates III. & IV.*)

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When six weeks ago I undertook the examination of the Organ of Jacobson and its relations in *Tupaia* and *Gymnura*, I was merely anxious to see if *Tupaia* agreed with *Macroscelides*, and *Gymnura* with *Erinaceus*, as an agreement would give further evidence of the value of this region of the skull as a basis of classification, and also strongly support the removal of *Macroscelides*, *Tupaia*, and allied genera from the Insectivora and the placing of them in a distinct order Menotyphla. As I have shown in Part I. of this paper, *Tupaia* agrees sufficiently closely with *Macroscelides*—both having the Polyprotodont Marsupial type of organ—to admit of their being placed in the same order; while *Gymnura* was shown to have the higher Eutherian type of organ met with in *Erinaceus*, *Felis*, *Ovis*, and all higher forms in which the organ is retained.

When I had finished the study of these two types, I thought it would be worth while to look at the condition in the aberrant African Golden Mole, *Chrysochloris*; and as Prof. J. P. Hill had two very fine specimens which I had given him some years ago—a newly-born *Chrysochloris hottentota* and a slightly older *Chrysochloris asiatica*—he very kindly had the heads sectioned so that I might examine them. The results were so interesting that it was necessary to go further with the research. Through the kindness of Mr. Oldfield Thomas, of the British Museum, I obtained the snout of a *Centetes* which I have examined, and also adult specimens of the common mole and shrew. Prof. Hill very kindly had sectioned for me the head of a very young mole. To these gentlemen, and also to Prof. Hill's laboratory assistant, Mr. F. Pittock, I am deeply indebted.

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* For explanation of the Plates see p. 354.

The Organ of Jacobson in Talpa. (Pl. III. figs. 1–7.)

Prof. Kitchen Parker in 1885 figured a number of sections of the nose of the young of *Talpa.* While these show the general structure and relations of the nasal cartilages, they do not clearly show the structures in the neighbourhood of the naso-palatine canal.

Though the young mole which I have examined has the cartilage in the anterior part of Jacobson's duct imperfectly chondrified, the young animal reveals the structures more clearly than does the adult in which the bones are so highly ossified and anchylosed.

In the anterior part of the nose there is little worthy of special note. One unusual feature is the thinning out and perforation of the cartilage of the septum a short distance behind the plane of the nostril. As the sections of the snout have been cut of uniform thickness, the number of the section figured or described will indicate the situation of the various features. This anterior perforation of the septal cartilage is between sections 19 and 22.

Immediately behind the perforation the upper part of the septum begins to thicken. Fig. 1 represents section 36. The thick alinasal cartilage is seen curving round and united with the thick outer part of the anterior nasal-floor cartilage. Outside the cartilage is seen the lacrimal duct, and inside, the duct of the nasal gland.

From the plane of this last section to section 76, the nasal cavity is completely surrounded by cartilage. The upper part of the septal cartilage becomes gradually more thickened. From section 60 a median groove passes upwards into the lower part of the septum gradually dividing the cartilage into two. Fig. 2 represents section 74. Here the lower parts of the median cartilage are almost separated from the upper septal cartilage to form the recurrent cartilages. The anterior part of the premaxilla is seen; the bones of the two sides are not clearly separable.

Three or four sections beyond that shown in fig. 2 the recurrent cartilage is free from the base of the septum and also from the lower part of the alinasal. A similar condition occurs for about twenty sections. In section 96 is seen the anterior part of the naso-palatine canal.

Fig. 4 represents the condition at section 100. On the left side the duct of Jacobson's organ is seen opening into the canal. On the right side, the duct of the organ is seen lying above and slightly to the outer side of the canal. The anterior part of Jacobson's cartilage is seen lying above the duct. The recurrent cartilage is well developed.

Fig. 3 represents section 103. The duct of Jacobson's organ is seen immediately above the naso-palatine duct.

In fig. 5, which represents section 110, the naso-palatine duct is shown to be passing to the outer side of the Jacobson's duct, and Jacobson's cartilage coming to lie on the inner side of the duct. The palatine process of the premaxilla is seen on one side free from the premaxilla.

A few sections further back, as shown in fig. 7, which represents section 117, Jacobson's cartilage is united with the lower part of the recurrent cartilage, and the naso-palatine canal is seen to have opened into the nasal cavity. In the next four sections, veins are seen to pass through two fair-sized openings in the cartilage about the level of the upper part of the palatine process

In fig. 6 is represented section 126. Here the duct of Jacobson's organ is just about to open out into the organ proper. The palatine processes form flattened splints on the inner sides of the cartilages of Jacobson. A portion of the secondary palatal plate of the maxilla is seen in the section.

The organ of Jacobson as distinct from the duct extends from section 127 to section 178. The specimen examined is too young to show clearly the arrangement of blood-vessels in connection with the organ. Beyond section 178 the organ is continued into a glandular duct, which extends for ten more sections.

Talpa agrees with *Gymnura* in having feebly developed glandular ridges; in having practically no inferior turbinal in that part of the nose in which is situated the anterior part of Jacobson's organ; in having the lower half of the nasal septum converted into recurrent cartilages: and in Jacobson's organ having a long duct in front which opens into the anterior end of the naso-palatine canal. It differs in a number of details, such as the mode of opening of Jacobson's duct, the less forward extension of Jacobson's cartilage, in the arrangement of the blood vessels of the organ, and in the better development of the recurrent cartilages.

There can, however, I think be little doubt but that *Talpa* is allied to *Gymnura* and may conveniently be left in the old order Insectivora.

I have made a series of sections of the snout of an adult *Sorex*. Unfortunately, the specimen was not in the best state of preservation, and, further, the structures are so extremely ossified that it is difficult to interpret some of the parts, and a young specimen will require to be examined before one can speak with any confidence on the affinities. In certain features *Sorex* resembles *Centetes* even more than it does *Talpa*, and an examination of the nose of a late fœtus would probably reveal some interesting facts.

The Organ of Jacobson in Centetes. (Pl. III. figs. 8 14.)

The specimen examined was the snout of an adult *Centetes ecaudatus* in fairly good preservation. It was sectioned by hand.

In the anterior part of the snout the median septum is well developed and of about uniform width. On passing back, the upper and middle part becomes thickened; then a little further back the lower half widens out and becomes divided by a median cleft into the two recurrent cartilages, as seen in fig. 8. Though in this section the alinasal is seen detached from the recurrent cartilage, they are seen united a few sections further forward. If this section be compared with a corresponding section in *Talpa*, such as shown in fig. 2, it will be observed that though there are many minor differences there is considerable agreement. Even the somewhat corresponding section which I have figured in *Gymnura* will be seen to agree fairly well, while the corresponding section in *Tupaia* will be seen to differ very greatly.

On passing a little further back, the septal cartilage becomes divided into an upper and a lower part. The upper part soon becomes greatly reduced, and then completely lost, while the lower part is continued backwards as a rounded cartilaginous rod. In fig. 9 the section passes through the anterior part of the papilla. The recurrent cartilages lie by the base of the septum. The upper nasal cartilages are considerably reduced.

Fig. 10 represents a section further back. It shows the anterior part of the naso-palatine canal. On the one side, Jacobson's duct is seen opening into it. At this plane the only cartilaginous support of the ducts is the anterior extension of the posterior nasal-floor cartilage. The recurrent cartilage is still of large size.

Fig. 11 represents a section near the plane where the naso-palatine canal opens into the nasal cavity. The recurrent cartilage is greatly reduced. Jacobson's duct is seen supported by anterior processes of Jacobson's cartilage.

Fig. 12 represents a section a short distance behind that shown in fig. 11. A small process of the recurrent cartilage is still seen, and quite free from Jacobson's cartilage. Jacobson's cartilage is united at its outer lower side to the posterior nasal-floor cartilage. This is a most unusual condition, and, so far as I am aware, is only known elsewhere in *Procavia*.

In fig. 13 Jacobson's organ and the cartilage are well developed. There is a small nasal-floor cartilage still seen. The palatine processes are large and partly roof over the organ. Above the palatine process is seen the anterior end of the vomer.

Fig. 14 is considerably further back. The vomer nearly clasps the nasal septum. Jacobson's cartilage rests on the palatal plate of the maxilla. The palatal processes, though thin, are still of large size. In this same section, though not shown in the figure, is seen a large inferior turbinal supported by a slender turbinal bone, and further up on the outer nasal wall a very well developed glandular ridge.

Centetes presents a number of unusual characters. It agrees with *Gymnura* and *Talpa* in that Jacobson's organ has a long narrow duct which opens into the anterior end of the naso-palatine canal, but differs from both in the anterior part of Jacobson's cartilage being less developed. It differs from both in the greater development anteriorly of the inferior turbinal. It resembles *Gymnura* in having a single large blood-vessel along the outer side of the organ. In the loss of the upper part of the septal cartilage, it agrees with *Sorex*. I know of no other form besides *Centetes* in which the lower part of the septal cartilage is completely surrounded by the vomer, as it is a little behind the plane of Jacobson's organ.

Whether *Centetes* should be placed with *Gymnura* and *Talpa* in the order Insectivora, or placed in a separate order of the Cœnorhinata, the evidence from the structures in the nose does not conclusively show, and it will therefore be well at present to leave *Centetes* and its allies in a very distinct family or suborder of the Insectivora.

The Organ of Jacobson in Chrysochloris. (Plate IV.)

I have examined the organ and its relations in a newly-born *Chrysochloris hottentota*, and a somewhat older *Chrysochloris asiatica*. The former had a head-length of 12 mm., and the latter a head-length of 16 mm.

Fig. 1 represents section 40 of the nose of the newly-born *Chrysochloris hottentota*. The median septum is slender; the alinasals are very wide. In the general arrangement of the cartilages, and in the mode of opening of the naso-lacrimal duct, the agreement with *Tupaia* is fairly close.

Fig. 2 represents section 47. It will be unnecessary in the present paper to discuss the morphology of the small cartilages of the nasal valve, but this section shows a remarkable recurrent process from the outer border of the alinasal. The only other mammal I know of which possesses a similar structure is *Echidna*.

In fig. 3, which represents section 55, the most anterior part of the premaxilla is cut through. The alinasal is continuous with the anterior nasal-floor cartilage, and a very sharp fold passes into the inferior turbinal.

Fig. 4 represents section 64. Here the lower part of the premaxilla is cut across as well as the lateral. The nasal-floor cartilage is no longer connected with the alinasal. The septal cartilage shows the first indications of separating into upper and lower parts.

In fig. 5, which represents section 69, we see the division of the septal cartilage into upper and lower parts, and the commencing division of the lower into the two recurrent cartilages. In this and the previous sections, the great encroachment on the nasal cavity by the folding of the mucous membrane is seen to be in marked contrast to the condition seen in *Talpa*, *Gymnura*, and *Centetes*.

Fig. 6, which represents section 86, cuts through the first incisors. The premaxillaries are sending up processes which form the bases of the palatine processes. The recurrent cartilages resemble considerably those of the Diprotodont Marsupials, *Trichosurus* and *Pseudochirus*.

In fig. 7, which represents section 114, is seen the anterior part of the maxilla. Here the recurrent cartilage is even more Diprotodont-like than in the previous section figured. The section is through the anterior part of the papilla.

Fig. 8, which represents section 120, is through the naso-palatine canal. It will be observed that the canal opens directly up into the nose, as in the typical marsupials. Jacobson's cartilages have given off the outer bars.

Fig. 9 represents section 123. Here Jacobson's organ is seen opening directly into the lower part of the nasal cavity. This section is strikingly like figures I have given of Jacobson's organ in *Pseudochirus* and *Trichosurus*.

In fig. 10, which represents section 126, the organ is seen in its fullest development.

A short distance behind this last section a small but well chondrified posterior nasal-floor cartilage is developed. The cartilage on passing backwards comes to lie underneath the outer part of Jacobson's cartilage.

Figs. 11–13 represent three sections through Jacobson's organ in the young *Chrysochloris asiatica*. Section 11 is through the anterior end of the organ near where it opens into the lower part of the nasal cavity: section 12 is through the middle of the organ, and section 13 near its posterior end. One of the most remarkable characters of the sections is the folding-down of the inferior turbinal till it almost forms a secondary nasal floor. The organ itself is remarkable in having no outer vascular plexus nor, as is seen in most Marsupials and in *Gymnura*, *Centetes*, and *Tupaia*, a large vessel along the outer side. Further, while the organ in most mammals has a large gland or numerous glands opening into it posteriorly, *Chrysochloris* has mucous glands opening into it all along its upper border.

It will be observed that *Chrysochloris* differs in the structure of this region of the nose entirely from *Gymnura*, *Talpa*, and *Centetes*, and that while it agrees more with *Tupaia* and *Macroscelides*, the affinity is not close.

Conclusions.

The research into the structure of the anterior nasal region of the Insectivores, even though only a few of the more striking types have been examined, shows I think conclusively that the "Insectivora" is not a natural order. *Erinaceus*, *Gymnura*, *Talpa*, *Sorex*, and *Centetes* agree in each having an organ of Jacobson which ends in a long duct opening into the naso-palatine canal near its anterior part. Jacobson's cartilage in each passes forwards with the duct, and the naso-palatine canal is supported by an anterior process of the posterior nasal-floor cartilage. Whatever subdivision may on other grounds be made of these Insectivores they all belong to the Cœnorhinata, and agree with most higher mammals, such as the Carnivores and Ungulates.

Tupaia and *Macroscelides* agree in having a Polyprotodont marsupial type of structure, and cannot have any near affinity with the typical Insectivores, and the order Menotyphla to which they belong must be removed far from the Insectivora and placed in quite a different phylum and not far from the early Marsupials.

Chrysochloris, which has generally been regarded as allied to *Centetes*, is seen to be in no way closely related to it. Like *Tupaia*, *Chrysochloris* belongs to the Archæorhinata, but it cannot belong to the order Menotyphla. The resemblance of its nasal structures to those of the Diprotodont marsupials is puzzling, and until further work is done on the development of *Chrysochloris*, one must hesitate in discussing its affinities further.

In 1883 Dobson *, in discussing the affinities of *Chrysochloris*, wrote as follows:—"The natural relations of the species of the family are with the Centetidæ, which they resemble in the form of their molar teeth, in the absence of an interorbital constriction, in the position of the testes, and in some important myological characters; but they also present many most important differences . . . . such as the presence and peculiar development of the zygomatic arches, the presence of tympanic bullæ, and the very different form of the male generative organs, characters which, while indicating separation at a very remote period from the ancestral Centetidæ, do not ally them with any other family of recent Insectivora."

The peculiar structure of the molars has been the main character which has suggested an affinity with *Centetes*. But we find a similar type of teeth in the marsupial *Notoryctes*, and the similarity in the three genera is probably due to convergence, and does not indicate any affinity.

I hope shortly to undertake the study of the structure and development of the skull, and may be able to throw some further light on the affinities of *Chrysochloris*.

In the meantime I have no hesitation in removing it from the Insectivora, and placing it in a distinct order, for which the name Chrysochloridea, proposed by Dobson, may be retained.

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* A Monograph of the Insectivora, Systematic and Anatomical, Part II., 1883, p. 108.

EXPLANATION OF THE PLATES.

Lettering.

a.J.c., anterior process of Jacobson's cartilage; *b.v.*, blood-vessel; *d.J.o.*, duct of Jacobson's organ; *g.d.J.o.*, duct of gland leading into Jacobson's organ; *J.c.*, Jacobson's cartilage; *J.o.*, Jacobson's organ; *l.d.*, lacrimal duct; *Mx.*, maxilla; *Na.*, nasal; *n.f.c.*, nasal-floor cartilage; *n.g.d.*, nasal-gland duct; *n.p.c.*, naso-palatine canal; *o.b.J.c.*, outer bar of Jacobson's cartilage; *Pmx.*, premaxilla; *p.Pmx.*, palatine process of premaxilla; *r.a.n.*, recurrent process of alinasal; *r.c.*, recurrent cartilage; *Vo.*, vomer.

PLATE III.

Figs. 1-4. Sections through the snout of *Talpa europæa*. Young. × 15.
5-7. Sections through the snout of *Talpa europæa*. Young. Showing Jacobson's duct. × 34.
8-9. Sections through the snout of *Centetes ecaudatus*. × 5.
10-14. Sections through the snout of *Centetes ecaudatus*. Showing Jacobson's organ and its duct, and their relations. × 10.

PLATE IV.

Figs. 1-7. Sections through the snout of a newly-born *Chrysochloris hottentota* (greatest length 28 mm.). Figs. 1-4, × 15. Figs. 5-7, × 20.
8-10. Sections through the papillary region of newly-born *Chrysochloris hottentota*, showing the mode of opening of Jacobson's organ. × 30.
11-13. Sections through the snout of young *Chrysochloris asiatica*. (About half-grown.) × 17.

26. On the Anomodont Genera, *Pristerodon* and *Tropidostoma*. By Lieut. R. Broom, M.D., D.Sc., C.M.Z.S., R.A.M.C.

[Received April 27, 1915 : Read May 11, 1915.]

(Text-figures 1–4.)

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Pristerodon mckayi 355
P. raniceps 357
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P. brachyops 358
Tropidostoma microtrema 358

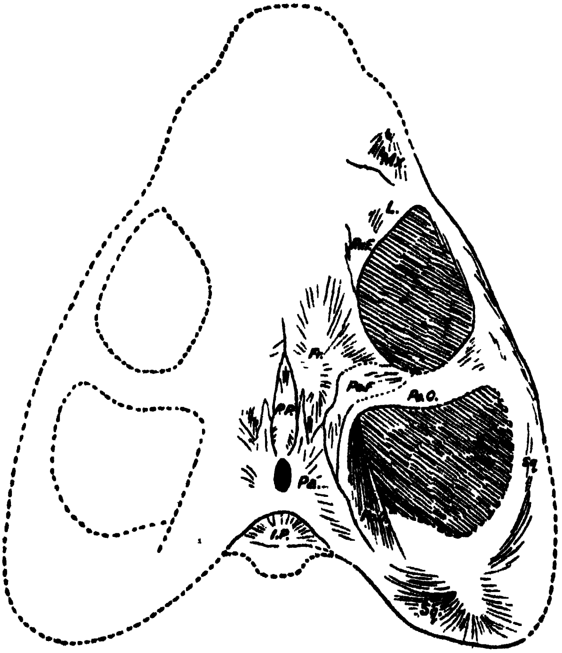
Pristerodon mckayi Huxley. (Text-fig. 1.)

In 1868 Huxley described, under the name *Pristerodon mckayi*, a fairly well-preserved skull of a small Anomodont reptile. Almost the whole of the right side is shown in good condition, and a considerable part of the left side. There are also associated with the specimen, besides the jaws belonging to the skull, a few other mandibular remains. Huxley apparently believed the animal to be a lizard, as he refers to the specimen as "a shattered lacertilian skull, having very much the general shape of that of *Rhynchosaurus*, being very broad posteriorly owing to the large size of the supratemporal fossa, and tapering anteriorly."

The skull when complete probably measured 87 mm. from the snout to the transverse plane of the squamosals, and the greatest breadth is about 70 mm. The interorbital measurement is 17 mm., and the intertemporal measurement 18·5 mm. The antero-posterior measurement of the orbit is 22 mm. In the type-skull there is no tusk, the animal having been a female, but a specimen in the South African Museum shows a *Dicynodon*-like tusk. The maxilla and the mandible have each, as shown by Huxley, a series of small teeth which have high crowns remarkable for being smooth in front and having about 8 or 9 relatively strong denticulations on the posterior side. The exact number of teeth appears to vary with age, but in the type there appear to be as many as 12 arranged somewhat irregularly and one or two being probably replacing teeth.

In structure the skull is typically Dicynodont. The frontals are large and pass backwards between the postfrontals and preparietal. The postfrontal is well developed, but in the specimen it is difficult to be quite sure of the sutures of its anterior and outer end, but they are probably as I have figured them, in dotted line. The postorbital is a larger bone which forms most of the postorbital arch and the whole of the inner border of the temporal fossa. The preparietal is long and narrow, and extends back nearly to the pineal foramen. It is, however, doubtful if it reaches the foramen, the appearances being rather in favour of the parietals just meeting in front of the foramen and shutting out the preparietal. The parietal is a fairly large flat bone. The interparietal is of moderate size and forms the upper part of the occiput. The squamosal is large and typically Dicynodont in character. The specimen shows part of the quadrato-jugal in front of the lower part of the squamosal.

Text-figure 1.



Skull of *Pristerodon mckayi* Huxley. Nat. size.
Left side and snout restored. B.M., R 1810.

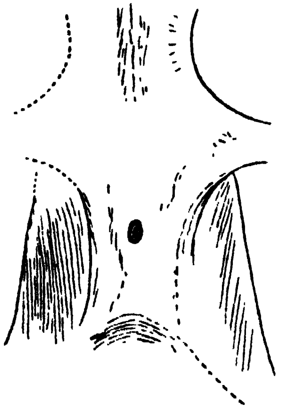
***Fr.*, frontal; *I.P.*, interparietal; *Ju.*, jugal; *L.*, lacrimal; *Mx.*, maxilla; *Na.*, nasal; *Pa.*, parietal; *Pal.*, palatine; *Pm.*, premaxilla; *Po.F.*, postfrontal; *Po.O.*, postorbital; *P.P.*, preparietal; *Pr.F.*, prefrontal; *Pt.*, pterygoid; *P.Vo.*, prevomer; *T.P.*, transpalatine.**

The lower jaw is not well preserved. As is seen in one of Huxley's figures, the angular has, as in *Dicynodon*, a fan-like expansion passing inwards and downwards. In front of the articulation is a plate of bone passing outwards and forwards, apparently part of the surangular.

PRISTERODON RANICEPS (Owen)*. (Text-fig. 2.)

In 1876 Owen briefly described, under the name *Oudenodon raniceps*, a small skull and jaws from the same locality, East London, as Huxley's type. Owen gives no figure of the specimens, but merely describes the skull as follows:—"The occipital condyle is low and broad; the lateral portions contributed by the exoccipitals simulate the Batrachian double condyle. The supraoccipital surface is much depressed. The temporal fossæ are large, with the long diameter lengthwise. The orbits appear to have been small."

Text-figure 2.



Frontal and parietal regions in *Pristerodon raniceps* (Owen). Nat. size. B.M., R 1650.

Lydekker, in his Catalogue of 1890, refers the specimens doubtfully to *Udenodon baini* Ow., believing that they were of a young individual.

It is rather remarkable that both Owen and Lydekker should have referred the specimens to *Oudenodon*, seeing that a considerable number of teeth are well exposed to view in the lower jaw. The teeth agree closely with those of *Pristerodon mckayi*, but the denticulations are relatively rather coarser.

The skull is much crushed, but probably measured about 92 mm. from the snout to the plane across the posterior borders of the squamosals, and the greatest breadth is about 80 mm. The interorbital measurement is 16 mm. and the intertemporal 28 mm. The antorbital portion of the skull appears to be relatively shorter than in *Pristerodon mckayi*. Unfortunately no sutures can be clearly made out in the present condition of the specimen, but, as will be seen by the figure I give of the parietal region, the relative proportions of the parts differ very considerably from those of the type species.

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* [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.]

In the lower jaw there appears to be a series of 6 teeth with some replacing ones.

Seeing that Owen's specimen came from the same locality as Huxley's I was inclined to regard them as belonging to the same species, but the differences in proportions appear to be sufficiently great to warrant us at least provisionally in regarding them as distinct.

PRISTERODON AGILIS (Broom).

In 1904 I described, in the Records of the Albany Museum, the skull of a small Anomodont found by me at Pearston. At that time it was not known that *Oudenodon* is the female of *Dicynodon*, and as the Capetown specimen of *Pristerodon mckayi* is tusked, and the new allied form which I discovered being tuskless, I placed it in a new genus and called it *Opisthoctenodon agilis*. As, however, the tusk is now known to be a sexual character, this species must be placed in Huxley's genus *Pristerodon*.

The skull is much smaller than in *P. mckayi* and narrower relatively, but in most characters it agrees closely, and the molars are very similar.

Pristerodon mckayi and *P. raniceps* both come from the *Pareiasaurus* zone, but *P. agilis* is from the *Endothiodon* zone.

PRISTERODON BRACHYOPS (Broom).

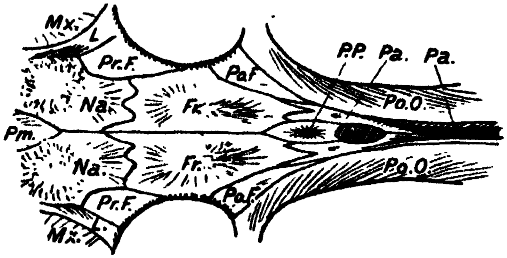
This species when described was also placed in the genus *Opisthoctenodon*. As the crowns of the molars are unknown it is impossible to be certain that it belongs to *Pristerodon*, but it agrees sufficiently to admit of its being placed here, at least provisionally. It is probably from the *Cistecephalus* zone.

TROPIDOSTOMA MICROTREMA (Seeley). (Text-figs. 3 & 4.)

In 1889 Seeley described an Anomodont occiput under the name *Dicynodon microtrema*. The occiput formed part of Mr. T. Bain's collection and was obtained, according to Mr. Watson, on the farm Tafelberg, in the Beaufort West district. In the British Museum there is a good series of Dicynodont skull-remains from the same locality, and the majority belong, I think there is little doubt, to the one species. Fortunately there are a number of snouts and a few mandibles. Both tusked males and tuskless females are represented, and most specimens show evidence of small molars behind the tusk, or caniniform process. The specimens differ considerably in size, doubtless due to difference in age, and the differences in dentition are probably due to the same factor. There appear to be normally four molars, but as age advances they become reduced to three, two, or one, and in old age get completely lost.

A small mandible shows the crowns of two teeth in fairly good preservation. They are seen to agree pretty closely with those of *Pristerodon*. Though the teeth are rather more robust, they are really relatively very much smaller. One might incline on the evidence of the teeth to place these large specimens in the genus *Pristerodon*, but the structure of the parietal region differs so considerably that it is necessary to place them in a different genus. The snout agrees so closely with *Dicynodon* except for the presence of the molars, that one has to consider whether it might not be possible that all species of *Dicynodon* had molars when young which they lost later. This, however, is hardly possible. In no species of *Dicynodon* have molars ever been detected—even where the skulls are manifestly of young animals. Of *Dicynodon platyceps* we know over a dozen skulls, from small ones about 3 inches to others over a foot in length. But in none is there any trace of molars. Further, the peculiar condition of the intertemporal region found in the present species is unknown in any species of *Dicynodon*. We may, therefore, safely conclude that *Dicynodon microtrema* Seeley must be placed in a distinct genus. Another specimen, figured by Seeley in 1889, was an occiput which he named *Dicynodon* (*Tropidostoma*) *dunni*. Lydekker regarded this specimen—quite rightly, I think—as belonging to the same species as that named *D. microtrema*. And if this be so we must accept the generic name *Tropidostoma* for the type.

Text-figure 3.



Bones of the frontal and parietal regions of the skull of *Tropidostoma microtrema* (Seeley). About ½ nat. size.

For lettering see text-fig. 1, p. 356.

Though there is no complete skull in the collection, one is fairly complete, and there are so many snouts, occiputs, and other portions, that practically every detail of the structure can be made out.

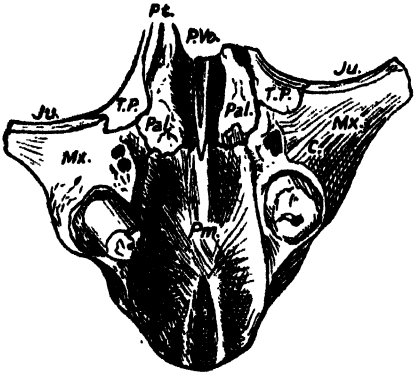
The skull, in what appears to be an adult male, measures from the snout to the plane cutting the posterior borders of the squamosals 266 mm., and the greatest width across the squamosals is about 220 mm.

The following are the other principal measurements :—

Measurement between the canines, 40 mm. to 48 mm.
Interorbital width, 25 mm.
Measurement across the nasal bosses, 44 mm. to 52 mm.
Interorbital measurement, 36 mm. to 38 mm.
Intertemporal measurement, 28 mm. to 36 mm.

The premaxilla is relatively narrow in front. It has the usual pair of palatal ridges seen in most Anomodonts. It forms much the larger part of the hard palate, and meeting the palatine behind shuts out the maxilla from the margin of the posterior nares. In the middle line the premaxilla meets the prevomer, as shown in the figure.

Text-figure 4.



Anterior palatal region of *Tropidostoma microtrema* (Seeley). ½ nat. size.

Showing the relations of the palatal elements and tooth-sockets behind the canines. B.M., R 860.

For lettering see text-fig. 1, p. 356.

The maxilla is very similar to that of *Dicynodon* except for the presence of molar teeth. With the premaxilla it forms the lower border of the nostril, meeting the septomaxilla. Its upper border articulates with the lacrimal, which completely separates it from the nasal.

In nearly all the specimens of *Tropidostoma microtrema* there are seen some molar teeth or tooth-sockets. In young specimens, which are about half the adult size, there are four molars, of which the first is the largest, and they decrease in size to the fourth. The four molars measure 10 mm. Only one specimen shows the crowns. These resemble closely the molars of *Pristerodon*, but those of *Tropidostoma* are rather stouter and the denticulation slightly coarser. In the 1st molar there are probably seven denticulations, and in the 3rd, five. As *Tropidostoma* approaches the adult condition the molars seem to be gradually lost. Some specimens show only three, others but two or one, and in old age all trace of even the sockets disappears.

In those specimens which are regarded as males there is a pair of powerful tusks. In the supposed females, in place of the tusks are, as in "*Oudenodon*," caniniform processes. One specimen (R 871) is remarkable for having on the right side a well-developed tusk, and on the left side no trace whatever of a tusk. This specimen is probably the oldest animal of the series, and I regard it as a female which has developed a tusk on the one side.

The septomaxilla lies within the nostril forming its lower wall.

The lacrimal extends forwards between the nasal and the maxilla, and meets the septomaxilla.

The relationships of the bones of the top of the skull will best be understood from the diagram I have given. The greater part of the figure is drawn from specimen R 860, but the anterior and posterior portions are from two other specimens. Nearly every suture is confirmed by more than one specimen.

The most noteworthy features of the upper side of the skull are the presence of thickened bosses on the nasals, and the development of the postorbitals and parietals into a pair of lateral crests with a deep groove between them.

The palate has already been figured by Lydekker; but as I think he is in error in a number of points, and as the whole structure of the anterior palatal region is exceedingly well shown in specimen R 860, I think it worthy of being figured again. The great size of the palatal portion of the premaxilla is seen and the relations of the palatine, transpalatine, and pterygoid bones to each other. The prevomer has its lower border developed as a pair of plates. In this *Tropidostoma* differs from *Dicynodon*, and agrees with *Endothiodon* and *Emydorhynchus*.

The occiput has been figured and described by Seeley.

27. On the Triassic Stegocephalians, *Brachyops*, *Bothriceps*, and *Lydekkerina*, gen. nov. By Lieut. R. Broom, M.D., D.Sc., C.M.Z.S., R.A.M.C.

[Received May 26, 1915: Read June 8, 1915.]

(Text-figures 1–3.)

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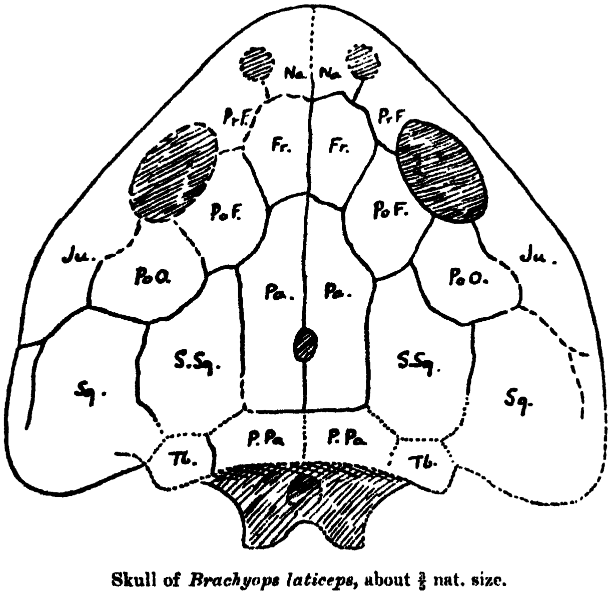
Bothriceps australis 364
Lydekkerina huxleyi 366

Brachyops laticeps Owen. (Text-fig. 1.)

In 1854 Owen described, under the name *Brachyops laticeps*, the skull of a small Stegocephalian from Mangali, Central India. Though the skull is fairly complete it is very badly weathered,

Text-figure 1.



Skull of *Brachyops laticeps*, about ⅗ nat. size.

Fr., Frontal; *Ju.*, Jugal; *L.*, Lacrimal; *Mx.*, Maxilla; *Na.*, Nasal; *Pa.*, Parietal; *Pmx.*, Premaxilla; *PoF.*, Postfrontal; *PoO.*, Postorbital; *Pr.F.*, Prefrontal; *P.Pa.*, Postparietal; *Q.J.*, Quadratojugal; *Sq.*, Squamosal; *S.Sq.*, Supra-squamosal (Supratemporal); *Tb.*, Tabular.

and very little can be made out beyond the impression of the inner sides of the upper cranial bones. Very little remains of the elements in front of the orbit and practically nothing of the tabular and postparietal regions.

The parietals, which are clearly paired, are unusually large and have between them a large pineal foramen. The anterior end of the parietal is in front of the transverse plane through the postorbital margin.

The frontal is relatively small. The postfrontal and postorbital are of about equal size—each a little larger than the orbit. The jugal has a very well-developed portion lying between the orbit and the quadratojugal and squamosal, and here there has evidently been a moderate-sized boss.

The squamosal is large and the suprasquamosal only a little smaller. The tabular has evidently been small and the postparietals short antero-posteriorly.

The occipital region slopes back from the postparietals, and the exoccipital condyles are considerably behind the plane of the quadrates.

In the figure I have given, the sutures in line are those seen on the specimen; those in broken line are from those of the opposite side; those in dot are hypothetical.

BOTHRICEPS AUSTRALIS Huxley. (Text-fig. 2.)

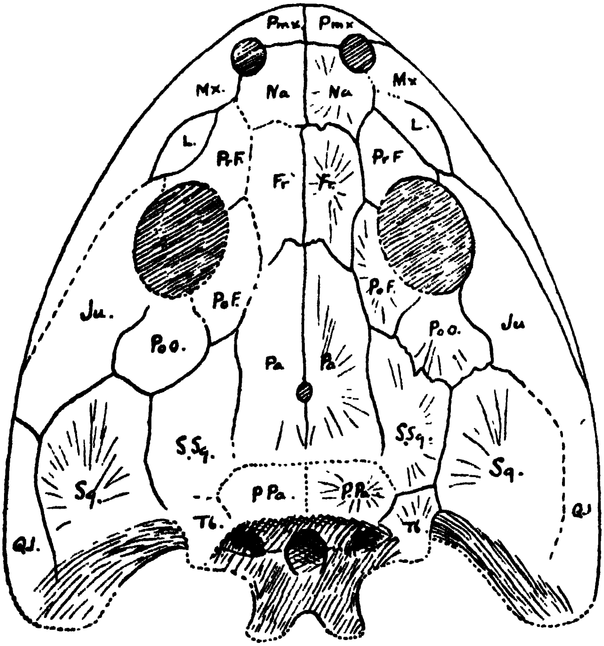
In 1859 Huxley described a small Stegocephalian from Australia, under the name *Bothriceps australis*. Though smaller than *Brachyops laticeps* it is fairly closely allied to it. Huxley gives reasons sufficient to show that it is at least specifically distinct. The few reasons he gives for regarding it as generically distinct are less conclusive. *Brachyops* has a broader skull, and the eye is placed further forward and more laterally than in *Bothriceps*, but in the imperfect state of the specimens no characters of generic importance can be seen to separate the two forms. There may, however, be in association with the anterior portion of the orbit in *Brachyops*, some differences in relations of the lacrimal, or septo-maxillary, or of the sensory grooves, or in the structure of the palate, which may be sufficient to separate the types into distinct genera, and in the meantime *Bothriceps* may be retained as possibly distinct.

The figure given by Huxley shows the sutures as preserved in the specimen. The new figure I give represents a restoration of the skull. As, however, every element of the upper side of the skull is shown on one side or the other, there is no element in any doubt, and the only sutures concerning which there is any doubt are indicated in dotted line.

The following are some of the more interesting points in the structure of the skull. The lacrimal is small, and nearly extends from the orbit to the nostril, but does not reach the border of either. The postfrontal is more than twice as long as broad. The jugal forms the lower margin of the orbit, but much the larger part of the bone is situated behind the orbit. The suprasquamosal is only about half the size of the squamosal.

The occiput slopes away from the postparietals as in *Brachyops*, but being much better preserved we can make out something of the structure in *Bothriceps*. The postparietal is well developed, and has a considerable part on the occipital aspect which articulates with the exoccipital. The tabular is smaller than the postparietal, and if only the upper surface were seen might be regarded as forming a small posterior horn, but the exoccipitals extend much behind it, and inferiorly and internally it articulates with what is probably the paroccipital.

Text-figure 2.



Skull of *Bothriceps australis*, about ⅜ nat. size.

For lettering see text-fig. 1.

The parasphenoid is large and there are no teeth on it.

Brachyops, *Bothriceps*, and *Batrachosuchus* are allied genera forming a very distinct family which may be called the

Brachyopidæ. It is interesting that one should be known only from India, one from Australia, and the third from South Africa.

LYDEKKERINA HUXLEYI (Lydekker), gen. nov. (Text-fig. 3.)

In 1890 Lydekker described a small Stegocephalian from the Orange Free State under the name *Bothriceps huxleyi*, believing the form to be allied to Huxley's *Bothriceps australis*. No later worker, so far as I am aware, has doubted the correctness of Lydekker's placing it in Huxley's genus. But as I hope to show that the South-African form differs very markedly from *Bothriceps*, and possibly even belongs to a different family, I propose to establish a new genus for it, which I have much pleasure in calling *Lydekkerina*, after Mr. R. Lydekker, who has so recently passed away, and whose work on South African fossil reptiles was extremely good.

The only known specimens of *Lydekkerina huxleyi* are four skulls, with some portions of the rest of the skeleton, in the British Museum, and a number of fairly good specimens in the Bloemfontein Museum; and all were obtained, I believe, from a locality near Edenburg, O.F.S.

The skull is about a half longer than broad. The orbits are moderately round and placed near the middle of the skull. The nostrils are large; and there is a very distinct otic notch bounded internally by a well-developed tabular.

The premaxillaries are fairly well developed and the maxillaries are long but very slender. The septo-maxillary, if developed as is probable, is entirely inside the nostril.

The nostril is large, and is separated from the maxilla by the lacrimal.

The lacrimal is very well developed, extending backwards from the nostril to near the orbit, and having on its inner side the nasal and prefrontal, and on its outer the maxilla and jugal.

The prefrontal is slightly larger than the lacrimal, and forms most of the anterior margin of the orbit.

The frontal is long and narrow. The prefrontal is also narrow, and of about the same length as the frontal. The postorbital is broad and slightly smaller than the prefrontal.

The jugal is long, and in the orbital region fairly wide. It lies above the maxilla, and along its upper border are the lacrimal, the prefrontal, the orbit, the postorbital, and the squamosal. Nearly as much of the jugal lies in front of the orbit as behind it.

The parietal is about as long as the frontal, but slightly broader. There is a small pineal foramen situated between the bones, and nearer to the anterior than to the posterior borders.

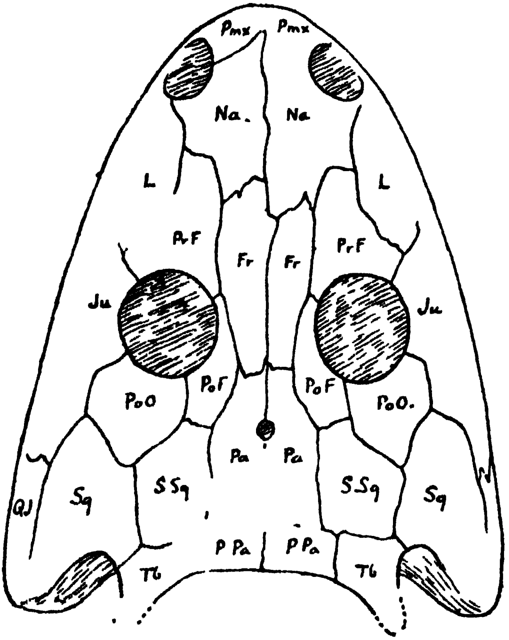
The suprasquamosal (supratemporal) lies on the outer side of the parietal. It is about the same size as the postorbital.

The squamosal is fairly large. It lies between the supra-squamosal and the quadratojugal, and passes downwards on the anterior wall of the otic notch to meet the pterygoid.

The quadratojugal is rather smaller than the squamosal.

The postparietal is a small quadrangular bone. On its outer side lies the tabular, which is produced backwards into what, when viewed from above, looks like a little posterior horn.

Text-figure 3.



Skull of *Lydekkerina huxleyi*, nat. size.
For lettering, see text-fig. 1.

The occiput is not sufficiently well preserved in any of the specimens to show the sutures, but the general structure can be satisfactorily made out. It differs from that of both *Brachyops* and *Bothriceps* in having the condyles relatively small, and in their not extending back behind the plane of the upper part of the postparietals, so that they are not seen when the skull is viewed from above. There is a relatively large opening between the exoccipital and postparietal on the one hand, and the par-occipital and tabular on the other.

The palate differs from that of *Bothriceps* in having on the parasphenoid, the prevomers, and the pterygoids, innumerable very minute teeth. In this it agrees with the large South African form *Rhinesuchus*.

The mandible, so far as can be seen in the specimens, agrees closely with that of *Trimerorhachis*. On the lower and outer sides can be seen a small splenial in front, with behind it a rather larger preangular, and behind this latter a large angular. The preangular has on its inner side relations to the prearticular and to what is probably the intercoronoid similar to those of *Trimerorhachis*. The structure of the jaw is best seen in the British Museum specimen R 506.

28. A List of the Snakes of Madagascar, Comoro, Mascarenes, and Seychelles. By G. A. Boulenger, F.R.S., F.Z.S.*

[Received May 12, 1915: Read May 25, 1915.]

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Ophidia. Keys to the identification of the Snakes of Madagascar, etc. 369

This list has been prepared on the same lines as the one recently published in these 'Proceedings'†, and likewise with the help of Mr. F. Kingsbury and M. G. de Witte. The reader is referred to the previous paper for an explanation of the terms used in the keys to the genera and species.

The fauna of the islands here dealt with is remarkable, not only for its very striking difference from that of the African continent, but also for the absence of Snakes dangerously poisonous to man (Elapine Colubrids, Viperids), with the exception of the two Sea-snakes which are known from the western parts of the Indian Ocean.

Synopsis of the Families.

I. Worm-like, with small inferior mouth; eyes hidden or visible under the head-shields; body covered with uniform imbricate scales above and beneath . . TYPHLOPIDÆ.

II. Mouth large; eyes exposed; body with enlarged shields beneath (except in Sea-snakes, with strongly compressed tail).

Frontal and parietal shields absent, or broken up into small shields . . . .. BOIDÆ.

Frontal and parietal shields present COLUBRIDÆ.

Family TYPHLOPIDÆ.

A single genus.

1. TYPHLOPS.

Schneid. Hist. Amph. ii. p. 339; Bouleng. Cat. Sn. i. p. 7.

Synopsis of the Species.

I. Præocular present.

A. Eyes distinct.

a. Snout rounded; præocular not much narrower than ocular; diameter of body 35 to 55 times in total length.

Nasal completely divided, the anterior portion extending to the upper surface of the head; 20 scales round middle of body .... *T. braminus.*

Nasal not completely divided; 20 scales round middle of body; præocular as broad as ocular . ... *T. comorensis.*

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* Published by permission of the Trustees of the British Museum.

† "A List of the Snakes of the Belgian and Portuguese Congo, Northern Rhodesia, and Angola," P. Z. S. 1915, p. 193.

Nasal not completely divided; 20 scales round middle of body, præocular narrower than ocular *T. microcephalus.*

Nasal not completely divided; 24 scales round middle of body *T. mucronatus.*

b. Snout with obtusely angular horizontal edge; nasal semi-divided; præocular much narrower than ocular.

Diameter of body 44–50 times in total length; 20–22 scales round middle of body *T. boettgeri.*

Diameter of body 39 times in total length; 26 scales round middle of body *T. decorsei.*

c. Snout with sharp horizontal edge; nasal completely divided; diameter of body 52–68 times in total length; 20 scales round middle of body. *T. arenarius.*

B. Eyes hidden; nasal incompletely divided, diameter of body 46 times in total length; 24 scales round middle of body *T. madagascariensis.*

II. Præocular absent; eyes hidden; snout with sharp horizontal edge; nasal completely divided; diameter of body 71–78 times in total length; 20 scales round middle of body *T. grandidieri.*

1. TYPHLOPS BRAMINUS.

Eryx braminus Daud. Hist. Rept. vii. p. 279.

Typhlops braminus Bouleng. Cat. Sn. i. p. 16.

Southern Asia; islands of the Indian Ocean; South Africa; Mexico (probably transported by human agency).

2. TYPHLOPS COMORENSIS Bouleng. Ann. & Mag. N. H. (6) iv. 1889, p. 361, and t. c. p. 21.

Comoro Islands.

3. TYPHLOPS MICROCEPHALUS Werner, Jahresh. Ver. Nat. Württemb. lxv. 1909, p. 60.

Madagascar.

4. TYPHLOPS MUCRONATUS.

Typhlops (Ophthalmidion) mucronatus Boettg. Zool. Anz. 1880, p. 279, and Abh. Senckenb. Ges. xii. 1881, p. 438, pl. i. fig. 1.

Typhlops mucronatus Bouleng. t. c. p. 37.

Madagascar (Nossi Be).

5. TYPHLOPS BOETTGERI Bouleng. t. c. p. 39, pl. ii. fig. 6.

Madagascar.

6. TYPHLOPS DECORSEI Mocquard, Bull. Mus. Paris, 1901, p. 255.

Madagascar.

7. TYPHLOPS ARENARIUS.

Onychocephalus arenarius Grandid. Ann. Sc. Nat. (5) xv. 1879, art. 20, p. 9.

Typhlops arenarius Bouleng. t. c. p. 49.

Madagascar.

8. **TYPHLOPS MADAGASCARIENSIS** Boettg. Abh. Senckenb. Ges. xi. 1877, p. 3, pl. i. fig. 1; Bouleng. t. c. p. 25.

Madagascar (Nossi Bé).

9. **TYPHLOPS GRANDIDIERI** Mocquard, Bull. Mus. Paris, 1905, p. 287.

Madagascar.

Family BOIDÆ.

Synopsis of the Genera.

I. Head distinct from neck; scales smooth or unicarinate.

Scales smooth; labials with deep pits . . ... *Corallus.*

Scales smooth; nasals separated by small scales; tail short (20–41 subcaudals) . . *Boa.*

Scales keeled; nasals separated by a pair of internasals; tail long (120–133 subcaudals) . . . . . *Casarea.*

II. Head not distinct from neck; scales tri- or quinquecarinate .. . *Bolieria.*

1. CORALLUS.

Daud. Hist. Rept. v. p. 106; Bouleng. Cat. Sn. i. p. 99.

1. **CORALLUS MADAGASCARIENSIS.**

Xiphosoma madagascariense Dum. & Bibr. Erp. Gén. vi. p. 549.
Corallus madagascariensis Bouleng. t. c. p. 103.

Madagascar.

2. BOA.

Linn. Syst. Nat. i. p. 373; Bouleng. Cat. Sn. i. p. 116.

Two species:

11–16 scales round the eye; scales in 59–65 rows . *B. dumerilii.*

6–9 scales round the eye; scales in 69–77 rows . . *B. madagascariensis.*

1. **BOA DUMERILII.**

Acrantophis dumerili Jan, Icon. Gen. p. 83, l. 1, pl. ii.
Boa dumerilii Bouleng. t. c. p. 120.

Madagascar.

2. **BOA MADAGASCARIENSIS.**

Pelophilus madagascariensis Dum. & Bibr. Erp. Gén. vi. p. 524.
Boa madagascariensis Bouleng. t. c. p. 120.

Madagascar.

3. CASAREA.

Gray, Zool. Miscell. p. 43; Bouleng. Cat. Sn. i. p. 121.

1. **CASAREA DUSSUMIERI.**

Boa dussumieri Schleg. Phys. Serp. ii. p. 396.
Casarea dussumieri Bouleng. t. c. p. 121.

Round Island, near Mauritius.

4. Bolieria.

Gray, Zool. Miscell. p. 46; Bouleng. Cat. Sn. i. p. 121.

1. Bolieria multicarinata.

Eryx multocarinata Boie, Isis, 1827, p. 513.
Bolieria multicarinata Bouleng. t. c. p. 122.
Round Island, near Mauritius.

Family Colubridæ.

Aglypha.

Synopsis of the Genera.

I. Pupil round; scales smooth (Madagascar and Comoro Islands).
  A. Body cylindrical; scales not oblique.
    1. Snout rounded; anal divided.
      a. Eye moderate or rather large; nostril between two nasals; subcaudals 65–160; scales in 17 or 19 rows.

Head short, not or but scarcely distinct from neck; frontal not narrower than supraocular ...... *Polyodontophis.*
Head moderately elongate, distinct from neck; frontal not narrower than supraocular, usually shorter than parietals . *Tropidonotus.*
Head elongate, distinct from neck; frontal, in the middle, narrower than supraocular, its length not less than that of parietals ...... *Dromicodryas.*

      b. Eye rather large; nasal single; scales in 19 rows; subcaudals 41 ...... *Compsophis.*
      c. Eye small; scales in 17 to 25 rows; subcaudals 35 to 64.
        α. Loreal present.

Nostril between the nasals and the internasal; frontal nearly twice as long as broad ...... *Liophidium.*
Nostril between the nasals; frontal not more than once and a half as long as broad ...... *Pseudoxyrhopus.*

        β. Loreal absent.

Nostril between the nasals and the internasal; frontal a little longer than broad; ventrals 221-255 ...... *Idiophis.*
Nostril between the nasals, frontal a little broader than long; ventrals 168 ...... *Pararhadinæa.*

    2. Snout pointed, strongly projecting; rostral very large, trihedral; scales in 21 or 23 rows; anal entire . *Lioheterodon.*
    3. Snout depressed, with horizontal edge; scales in 17 rows; anal divided ...... *Heteroliodon.*
  B. Body slightly compressed; scales narrow, oblique, in 17 rows ...... *Micropisthodon.*

II. Pupil vertically elliptic; body cylindrical (Seychelles and Mascarene Islands).

Scales keeled, in 17 rows; no loreal ...... *Lycognathophis.*
Scales smooth, in 21 or 23 rows ...... *Boodon.*
Scales smooth, in 17 rows ...... *Lycodon.*

1. Polyodontophis.

Bouleng. Faun. Ind., Rept. p. 301, and Cat. Sn. i. p. 181.

Three species:—

I. Scales in 17 rows.

Loreal deeper than long; frontal much shorter than parietals... *P. rhodogaster.*
Loreal as deep as long or longer than deep; frontal but slightly shorter than parietals ...... *P. torquatus.*

II. Scales in 19 rows ...... *P. mayottensis.*

1. POLYODONTOPHIS RHODOGASTER.

Herpetodryas rhodogaster Schleg. Phys. Serp. ii. p. 193.
Polyodontophis rhodogaster Bouleng. Cat. Sn. i. p. 182.
Madagascar.

2. POLYODONTOPHIS TORQUATUS.

Coronella torquata Bouleng. Ann. & Mag. N. H. (6) 1888, p. 103, pl. v. fig. 3.
Polyodontophis torquatus Bouleng. Cat. Sn. i. p. 183.
Madagascar.

3. POLYODONTOPHIS MAYOTTENSIS.

Ablabes rhodogaster, var. *mayottensis* Peters, Mon. Berl. Ac. 1873, p. 793.
Polyodontophis mayottensis Bouleng. Cat. Sn. i. p. 183.
Mayotta, Comoro Islands.

2. TROPIDONOTUS.

Kuhl, Bull. Sc. Nat. ii. 1824, p. 81 ; Bouleng. Cat. Sn. i. p. 192.
Liopholidophis Mocquard, Bull. Mus. Paris, 1904, p. 302.

Synopsis of the Species.

I. Scales in 17 rows.	
Rostral nearly as broad as deep ; eye rather small ; subcaudals 72–152	*T. sexlineatus.*
Rostral much broader than deep ; eye rather large ; subcaudals 97–160	*T. dolichocercus.*
Rostral twice as broad as deep ; subcaudals 221	*T. grandidieri.*
II. Scales in 19 rows ; subcaudals 68–104.	
Frontal once and a half as long as broad	*T. stumpffii.*
Frontal once and two-thirds to twice as long as broad	*T. lateralis.*

1. TROPIDONOTUS SEXLINEATUS.

Dromicus sexlineatus Günth. Ann. & Mag. N. H. (5) ix. 1882, p. 264, fig.
Tropidonotus sexlineatus Bouleng. t. c. p. 246.
Madagascar.

2. TROPIDONOTUS DOLICHOCERCUS.

Dromicus dolicocercus Peracca, Boll. Mus. Torin. vii. 1892, no. 112, pl. i. fig. i.
Tropidonotus dolichocercus Bouleng. t. c. p. 246.
Madagascar.

3. TROPIDONOTUS GRANDIDIERI.

Liopholidophis grandidieri Mocquard, Bull. Mus. Paris, 1904, p. 304.
Madagascar.

4. TROPIDONOTUS STUMPFFII.

Dromicus stumpffii Boettg. Zool. Anz. 1881, p. 358.
Tropidonotus stumpffii Bouleng. t. c. p. 247.
? *Liophidium gracile* Mocquard, Bull. Mus. Paris, xiv. 1908, p. 261.
Madagascar.

5. TROPIDONOTUS LATERALIS.

Leptophis lateralis, part., Dum. & Bibr. Erp. Gén. vii. p. 544.
Tropidonotus lateralis Bouleng. t. c. p. 248.
Madagascar.

3. DROMICODRYAS.

Bouleng. Cat. Sn. i. p. 189.

Two species: –

Subcaudals 81–117; usually two light dorsal stripes . *D. bernieri.*
Subcaudals 108–122; four black dorsal stripes . . . . *D. quadrilineatus.*

1. DROMICODRYAS BERNIERI.

Herpetodryas bernierii Dum. & Bibr. Erp. Gén. vii. p. 211, pl. lxvi.
Dromicodryas bernieri Bouleng. t. c. p. 189.
Madagascar.

2. DROMICODRYAS QUADRILINEATUS.

Herpetodryas quadrilineatus Dum. & Bibr. t. c. p. 212.
Dromicodryas quadrilineatus Bouleng. t. c. p. 190.
Madagascar.

4. COMPSOPHIS.

Mocquard, CR. Soc. Philom. 1894, no. 17, p. 8.

1. COMPSOPHIS ALBIVENTRIS Mocquard, l. c.

Madagascar.

5. LIOPHIDIUM.

Bouleng. Cat. Sn. iii. p. 598.

1. LIOPHIDIUM TRILINEATUM Bouleng. t. c. p. 599.

Madagascar.

6. PSEUDOXYRHOPUS.

Günth. Ann. & Mag. N. H. (5) vii. 1881, p. 359; Bouleng. Cat. Sn. i. p. 314.
Rhabdotophis Werner, Jahresh. Nat. Ver. Württemb. lxv. 1909, p. 58.

Seven species :—

I. Scales in 25 rows; loreal twice as long as deep; frontal nearly as broad as long	***P. microps.***
II. Scales in 21 rows.	
8 upper labials, 4th and 5th entering eye; rostral just visible from above	***P. heterurus.***
8 upper labials, 4th and 5th entering eye; portion of rostral visible from above at least half as long as its distance from the frontal	***P. quinquelineatus.***
7 upper labials, 3rd and 4th entering eye	***P. ambreensis.***
III. Scales in 19 rows	***P. imerinæ.***
IV. Scales in 17 rows.	
Rostral broader than deep; ventrals 183; subcaudals 64	***P. occipitalis.***
Rostral deeper than broad; ventrals 167; subcaudals 37	***P. subcaudalis.***

1. PSEUDOXYRHOPUS MICROPS Günth. Ann. & Mag. N. H. (5) vii. 1881, p. 359, fig.; Bouleng. t. c. p. 315, & iii. p. 613.

Pseudoxyrhopus dubius Mocquard, Bull. Mus. Paris, 1904, no. 6, p. 305.

Madagascar.

2. PSEUDOXYRHOPUS HETERURUS.

Homalocephalus heterurus Jan, Arch. Zool. Anat. Phys. ii. 1863, p. 286.

Pseudoxyrhopus heterurus Bouleng. Cat. Sn. i. p. 315.

Madagascar.

3. PSEUDOXYRHOPUS QUINQUELINEATUS.

Liophis quinquelineatus Günth. Ann. & Mag. N. H. (5) vii. 1881, p. 359, fig.

Pseudoxyrhopus quinquelineatus Bouleng. t. c. p. 315.

Madagascar.

4. PSEUDOXYRHOPUS AMBREENSIS Mocquard, CR. Soc. Philom. 1894, no. 9, p. 4; Bouleng. Cat. Sn. iii. p. 613.

Madagascar.

5. PSEUDOXYRHOPUS IMERINÆ.

Liophis imerinæ Günth. Ann. & Mag. N. H. (6) v. 1890, p. 71.

Pseudoxyrhopus imerinæ Bouleng. Cat. Sn. i. p. 316.

Madagascar.

6. PSEUDOXYRHOPUS OCCIPITALIS Bouleng. Cat. Sn. iii. p. 613.

Madagascar.

7. PSEUDOXYRHOPUS SUBCAUDALIS.

Rhabdotophis subcaudalis Werner, Jahresh. Nat. Ver. Württemb. lxv. 1909, p. 58.

Madagascar.

7. IDIOPHIS.

Mocquard, Bull. Mus. Paris, 1901, p. 252.

1. IDIOPHIS VAILLANTI Mocquard, l. c. and Bull. Soc. Philom. (9) iv. 1902, p. 14, pl. i. fig. 3.
Madagascar.

8. PARARHADINÆA.

Boettg. in Voeltzk. Reise Ostafr. iii. p. 325.

1. PARARHADINÆA MELANOGASTER Boettg. t. c. p. 326.
Madagascar (Nossi Bé).

9. HETEROLIODON.

Boettg. in Voeltzk. Reise Ostafr. iii. p. 313.

1. HETEROLIODON TORQUATUS Boettg. l. c. pl. xxvi. fig. 4.
Madagascar.

10. LIOHETERODON.

Dum. & Bibr. Erp. Gén., Atlas, pl. lxix.; Bouleng. Cat. Sn. i. p. 268.

Three species:—

Scales in 23 rows; ventrals 209–216; præfrontals separating internasals from frontal	*L. madagascariensis.*
Scales in 23 rows; ventrals 191–194; internasals in contact with frontal	*L. geayi.*
Scales in 21 rows; ventrals 159–170; internasals in contact with frontal	*L. modestus.*

1. LIOHETERODON MADAGASCARIENSIS.
Heterodon madagascariensis Dum. & Bibr. op. cit. vii. p. 776, pl. lxix.
Lioheterodon madagascariensis Bouleng. t. c. p. 269.
Madagascar.

2. LIOHETERODON GEAYI Mocquard, Bull. Mus. Paris, 1905, p. 289.
Lioheterodon voeltzkovii Boettg. in Voeltzk. Reise Ostafr. iii. p. 313, pl. xxviii.
Madagascar.

3. LIOHETERODON MODESTUS.
Heterodon modestus Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 356.
Lioheterodon modestus Bouleng. t. c. p. 269.
Madagascar.

11. MICROPISTHODON.

Mocquard, CR. Soc. Philom. 1894, no. 17, p. 7.

1. MICROPISTHODON OCHRACEUS Mocquard, l. c. p. 8.
Madagascar (Nossi Bé).

12. LYCOGNATHOPHIS.

Bouleng. Cat. Sn. i. p. 317.

1. LYCOGNATHOPHIS SECHELLENSIS.

Psammophis seychellensis Schleg. Phys. Serp. ii. p. 212.
Lycognathophis sechellensis Bouleng. t. c. p. 317.
Seychelles.

13. BOODON.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 460; Bouleng. Cat. Sn. i. p. 327.

1. BOODON GEOMETRICUS.

Lycodon geometricus Schleg. Phys. Serp. ii. p. 111.
Boodon geometricus Bouleng. t. c. p. 329.
Seychelles.

14. LYCODON.

Boie, Isis, 1827, p. 521; Bouleng. Cat. Sn. i. p. 348.

1. LYCODON AULICUS.

Coluber aulicus Linn. Mus. Ad. Frid. i. p. 29, pl. xii. fig. 2.
Lycodon aulicus Bouleng. t. c. p. 352.
Introduced in the Mascarene Islands.

Opisthoglypha.

Synopsis of the Genera.

1. Præfrontal not in contact with the upper labials; a loreal separating the nasal from the præocular.

A. Pupil round.

Scales in 19 rows; tail moderate or short (subcaudals 31–76); anal entire	***Geodipsas.***
Scales in 21 rows; tail long (subcaudals 121–175); anal divided; loreal once and a half to thrice as long as deep	***Ithycyphus.***

B. Pupil vertically elliptic.

1. Body cylindrical.

Scales keeled, in 19 rows; snout ending in a long appendage	***Langaha.***
Scales keeled, in 25 rows; subcaudals single	***Alluaudina.***

Scales smooth, in 25 to 29 rows; eye separated from the labials by suboculars	*Eteirodipsas.*

2. Body compressed; scales smooth, in 17 to 25 rows.

Snout rounded	*Stenophis.*
Snout much depressed, broad, truncate	*Lycodryas.*
II. Præfrontal in contact with upper labials, separating the loreal from the præocular; nasal entire or semidivided; scales in 17 rows	*Mimophis.*

1. GEODIPSAS.

Bouleng. Cat. Sn. iii. p. 32.

Two species:—

A single loreal; ventrals 172–189; subcaudals 55–76	*G. infralineata.*
Two superposed loreals; ventrals 137; subcaudals 31	*G. boulengeri.*

1. GEODIPSAS INFRALINEATA.

Tachymenis infralineatus Günth. Ann. & Mag. N. H. (5) ix. 1882, p. 265.

Geodipsas infralineata Bouleng. l. c. pl. iii. fig. 1.

Madagascar.

2. GEODIPSAS BOULENGERI.

Tachymenis boulengeri Peracca, Boll. Mus. Torin. vii. 1892, no. 112, p. 3.

Geodipsas boulengeri Bouleng. l. c.

Madagascar.

2. ITHYCYPHUS.

Günth. Ann. & Mag. N. H. (4) xi. 1873, p. 374; Bouleng. Cat. Sn. iii. p. 34.

Two species:—

Præocular in contact with frontal; loreal twice to thrice as long as deep; three postoculars	*I. goudoti.*
Præocular not reaching frontal; loreal once and a half to twice as long as deep; two (rarely three) postoculars	*I. miniatus.*

1. ITHYCYPHUS GOUDOTI.

Herpetodryas goudoti Schleg. Phys. Serp. ii. p. 187.

Ithycyphus goudoti Bouleng. l. c.

Madagascar.

2. ITHYCYPHUS MINIATUS.

Coluber miniatus Schleg. t. c. p. 148.

Ithycyphus miniatus Bouleng. t. c. p. 35.

Madagascar; Comoro Islands.

3. LANGAHA.

Bruguière, Journ. de Phys. xxiv. 1784, p. 132; Bouleng. Cat. Sn. iii. p. 35.

Synopsis of the Species.

I. A single supraocular; rostral appendage pointed.

Rostral appendage at least twice as long as snout, ensiform, not serrated *L. nasuta.*

Rostral appendage once and a half to once and two-thirds as long as snout, tapering to a sharp point, and serrated above at the end *L. intermedia.*

Rostral appendage not more than once and a half as long as snout, serrated above and beneath *L. crista-galli.*

II. Three supraoculars, in addition to an erect horn-like scale above the eye; rostral appendage not much longer than snout, very obtuse, grooved beneath *L. alluaudi.*

1. **LANGAHA NASUTA** Shaw, Nat. Misc. xxii. pl. cmlxviii.; Bouleng. t. c. p. 36.

Madagascar.

2. **LANGAHA INTERMEDIA** Bouleng. Ann. & Mag. N. H. (6) i. 1888, p. 105, pl. v. fig. 6; and t. c. p. 37.

Madagascar.

3. **LANGAHA CRISTA GALLI** Dum. & Bibr. Erp. Gen. vii. p. 806, pl. lxxi.; Bouleng. l. c.

Madagascar.

4. **LANGAHA ALLUAUDI** Mocquard, Bull. Mus. Paris. 1901, p. 253.

Madagascar.

4. ALLUAUDINA.

Mocquard, CR. Soc. Philom. 1894, no. 17, p. 9; Bouleng. Cat. Sn. iii. p. 38.

1. **ALLUAUDINA BELLYI** Mocquard, l. c.; Bouleng. l. c.

Madagascar.

5. ETEIRODIPSAS.

Jan, Elenco sist. Ofid. p. 105; Bouleng. Cat. Sn. iii. p. 38.

1. **ETEIRODIPSAS COLUBRINA.**

Dipsas colubrina Schleg. Phys. Serp. ii. p. 273.
Eteirodipsas colubrina Bouleng. t. c. p. 39.
Madagascar.

6. STENOPHIS.

Bouleng. Cat. Sn. iii. p. 39.

Synopsis of the Species.

I. Scales in 17 or 19 rows; internasals much shorter than the præfrontals.

A. Scales in 17 rows; ventrals 187; subcaudals 67 pairs... *S. guentheri.*

B. Scales in 17 rows; ventrals 228–276.

Posterior chin-shields a little shorter than the anterior and in contact with each other; ventrals 229–248; subcaudals 103–125, all or greater part in pairs .... *S. granuliceps.*

Posterior chin-shields longer than the anterior and in contact with each other; ventrals 228; subcaudals 110, greater part in pairs .... *S. inornatus.*

Posterior chin-shields shorter than the anterior and separated by scales; ventrals 255–276; subcaudals 93–116, all or greater part single .... *S. gaimardii.*

C. Scales in 19 rows; ventrals 243; subcaudals 126, single. *S. maculatus.*

II. Scales in 21 to 25 rows.

A. Internasals much shorter than the præfrontals; scales in 21 rows; ventrals 173; subcaudals 157 pairs .... *S. longicauda.*

B. Internasals nearly as long as, or a little longer than the præfrontals.

1. Loreal separated from the eye by the præocular; subcaudals 152–159, single.

Posterior chin-shields large and in contact with each other; scales in 21 or 23 rows; ventrals 225–236 .... *S. arctifasciatus.*

Posterior chin-shields very small or absent; scales in 23 or 25 rows; ventrals 251–265 .... *S. variabilis.*

2. Loreal entering the eye; scales in 23 rows; ventrals 226; subcaudals 106 pairs .... *S. betsileanus.*

1. STENOPHIS GUENTHERI Bouleng. t. c. p. 40, pl. iv. fig. 1.

Madagascar.

2. STENOPHIS GRANULICEPS.

Dipsas (*Heterurus*) *gaimardi*, var. *granuliceps* Boettg. Abh. Senck. Ges. xi. 1877, p. 14, pl. i. fig. 3.

Stenophis granuliceps Bouleng. t. c. p. 41.

Madagascar.

3. STENOPHIS INORNATUS Bouleng. t. c. p. 42.

Madagascar.

4. STENOPHIS GAIMARDII.

Dipsas gaimardii Schleg. Phys. Serp. ii. p. 293.

Stenophis gaimardii Bouleng. t. c. p. 42.

Madagascar; Comoro Islands.

5. STENOPHIS MACULATUS.

Dipsadoboa maculata Günth. Cat. Col. Sn. p. 183.

Stenophis maculatus Bouleng. t. c. p. 43, pl. iv. fig. 2.

Madagascar (?).

6. **Stenophis longicauda** Boettg. in Voeltzk. Reise Ostafr. iii. p. 315, pl. xxvi. fig. 7.

Madagascar.

7. **Stenophis arctifasciatus.**

Heterurus arctifasciatus Dum. & Bibr. Erp. Gén. vii. p. 1176.
Stenophis arctifasciatus Bouleng. t. c. p. 43.
Madagascar.

8. **Stenophis variabilis** Bouleng. t. c. p. 43, pl. iv. fig. 3.

Madagascar.

9. **Stenophis betsileanus.**

Dipsas betsileana Günth. Ann. & Mag. N. H. (5) vi. 1880, p. 238.
Stenophis betsileanus Bouleng. t. c. p. 44, pl. iv. fig. 4.
Madagascar.

7. Lycodryas.

Günth. Ann. & Mag. N. H. (5) iii. 1879, p. 48; Bouleng. Cat. Sn. iii. p. 44.

1. **Lycodryas sancti-johannis** Günth. l. c.; Bouleng. t. c. p. 45, pl. iii. fig. 2.

Comoro Islands.

8. Mimophis.

Günth. Ann. & Mag. N. H. (4) i. 1868, p. 421; Bouleng. Cat. Sn. iii. p. 171.

1. **Mimophis mahfalensis.**

Psammophis mahfalensis Grandid. Rev. et Mag. Zool. xix. 1867, p. 234.
Mimophis mahfalensis Bouleng. l. c.
Madagascar.

Proteroglypha.

(Sea-Snakes, with oar-shaped, compressed tail.)

Two genera :—

No distinct ventrals; frontal at least as long as snout	*Hydrus.*
Ventrals distinct, but very small; frontal shorter than its distance from end of snout	*Enhydrina.*

1. HYDRUS.

Schneid. Hist. Amph. i. p. 233; Bouleng. Cat. Sn. iii. p. 266.

1. HYDRUS PLATURUS.

Anguis platura Linn. S. N. i. p. 391.
Hydrus platurus Bouleng. t. c. p. 267.
Indian and Pacific Oceans.

2. ENHYDRINA.

Gray, Cat. Sn. p. 47; Bouleng. Cat. Sn. iii. p. 302.

1. ENHYDRINA VALAKADIEN.

Hydrus valakadyn Boie, Isis, 1827, p. 554.
Enhydrina valakadien Bouleng. l. c.
Indian Ocean, eastwards to Papuasia.

29. On a Blood-sucking Gamasid Mite (*Ichoronyssus serpentium*, sp. n.?), parasitic on Couper's Snake. By STANLEY HIRST, F.Z.S.*

[Received April 30, 1915: Read May 25, 1915.]

(Text-figures 1 & 2.)

It is quite probable that the species dealt with below is identical with that to which Gervais gave the name *Dermanyssus natricis* in the year 1844, but as there is some doubt on this point, I am describing it under a new name. Gervais says very little about the structure of his species, and the only account of it which is at all complete is that written by Paul Mégnin in 1884, who created a new genus (*Ophionyssus*) for it. References to several earlier papers and works in which this parasitic mite is mentioned are given in Mégnin's paper. Unfortunately he makes a serious mistake in his description, stating that there is no ventral plate (plastron) on the lower surface of the body, and that the "oviducte" has the form of a longitudinal slit. It is quite clear that he mistook the narrow genito-ventral plate for the genital opening itself. In reality, the genital aperture is quite normal in appearance, being transverse and protected by the usual delicate chitinous flap or operculum, which is joined posteriorly to the genito-ventral plate. *Ophionyssus natricis* is mentioned by G. Canestrini in his 'Prospetto dell' Acarofauna Italiana,' and also by Prof. Antonio Berlese in his well-known work on the Acari, etc. of Italy; but these authors did not have the opportunity of examining specimens, and the latter expresses doubt as to the validity of the genus, rightly considering it as probably identical with *Leiognathus* Can. [=*Ichoronyssus* Kolenati].

It may be of interest to note that, in having two dorsal shields and also minute intermediate platelets, the adult females described below present a strong resemblance to the protonymph stage of certain other species of *Ichoronyssus* (for instance, to that of *I. bacoti* mihi).

Genus ICHORONYSSUS Kolenati.

Dermanyssus (ad part.) Gervais, in Ins. Apt. iii. p. 223 (1844); *Ichoronyssus* Kolenati, Wien. ent. Monatschr. ii. p. 5 (1858); id. Sitz. K. Akad. Wiss. Wien, xxxv. p. 173 (1859); *Ophionyssus* Mégnin, Bull. Soc. Zool. France, p. 109 (1884); *Ophionyssus* + *Leiognathus* G. Canestrini, in Prospet. Acarof. Ital. part i. p. 121 (1885); *Liponyssus* of some recent authors, but probably not that of Kolenati.

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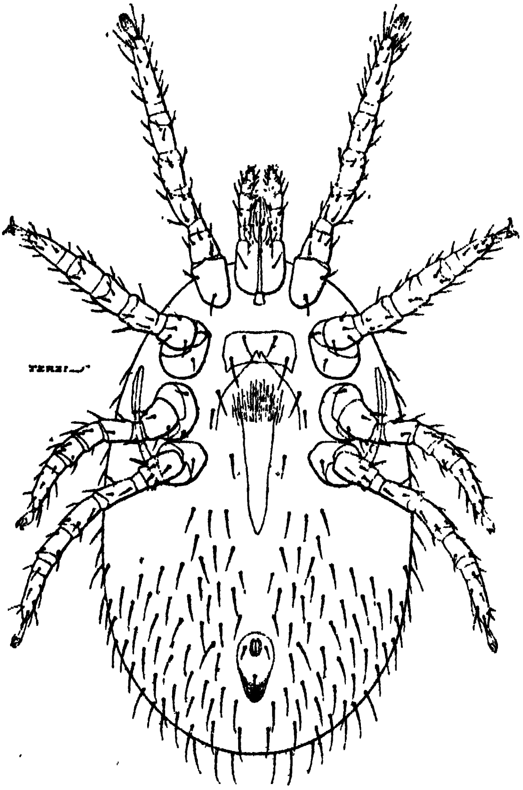
ICHORONYSSUS SERPENTIUM, sp. n.?

♀. *Body* long oval in shape. *Dorsal surface* furnished with numerous hairs, which are not very long and are distinctly curved; apparently the fine little offshoot or hair present near the end of the hairs of certain other species of *Ichoronyssus* (for instance, on those of *I. bacoti*) does not occur on the hairs of this species. There are two *dorsal shields*, the anterior one being comparatively large (length ·3 mm., width ·27 mm.), but the posterior one, which is situated far back near the hinder end of the dorsal surface, is very small and inconspicuous. Outline of *anterior shield* shaped almost like that of a lemon; twenty hairs

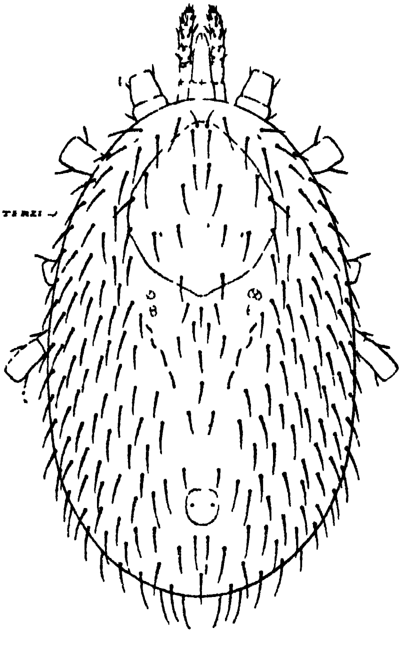
Text-figure 1.



Ichoronyssus serpentium, ♀. Ventral view.

are present on its surface, six pairs practically forming a longitudinal series running down the middle and four other hairs being placed on each side, three of these lateral hairs being marginal. The minute *posterior shield* is not provided with any hairs, but one or more pairs of minute punctations, which may possibly represent the sockets of hairs, occur on it. On each side of the dorsal surface, a little behind the anterior shield, there are two distinct but very minute platelets, and they are followed posteriorly by about four very inconspicuous

Text-figure 2.



Ichoronyssus serpentinum, ♀. Dorsal view.

(obsolete) linear platelets, arranged in a longitudinal series. Numerous hairs are present on the posterior part of the ventral surface, but they are shorter than those on the dorsal surface. *Sternal plate* trapezoidal in shape, being much wider than long and furnished with only two pairs of hairs. *Genital aperture* normal in situation and appearance; it is protected by the usual thin membranous operculum. *Genito-ventral plate* long and very narrow, the hinder end being sharply pointed. *Anal* *plate* pear-shaped, and it has the three usual hairs on its surface. *Peritreme* slender and rather short; it reaches a little further forwards than the coxa of the third leg. Fingers of *chelicera* short, and apparently without any trace of teeth. *Legs.* First leg the longest, and the fourth leg also long, the legs of the second and third pairs being shorter. Ventral surface of coxæ without any strong spurs, only fine setæ or hairs being present. There is, however, a very slight projecting spinule at the distal end of the inner surface of the coxa of the first leg.

Length ·9 mm.

Colour (in spirit) reddish brown.

Material. Five female examples found on a Couper's Snake in the London Zoological Gardens (May 5th, 1909).

30. On the Feet and Glands and other External Characters of the Paradoxurine Genera *Paradoxurus*, *Arctictis*, *Arctogalidia*, and *Nandinia*. By R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of Mammals.

[Received May 11, 1915 · Read June 8, 1915.]

(Text-figures 1–10.)

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This paper, the result of researches carried on at intervals for several years in the Society's Prosectorial Department, may be regarded as a continuation of the one dealing with the genera of Viverrinæ which was published in the 'Proceedings' for March 1915 (pp. 131–149). Its subject-matter is treated on the same general lines as those therein adopted, and its main purpose is to show first that the genera discussed, hitherto diagnosed mainly by cranial and dental characters, may be equally well, perhaps better, distinguished by the cutaneous features examined; and secondly, that these features fully justify the conclusion, hinted at but not adopted by Mivart, that the Viverrine and Paradoxurine genera should be relegated to distinct subfamilies of the Viverridæ.

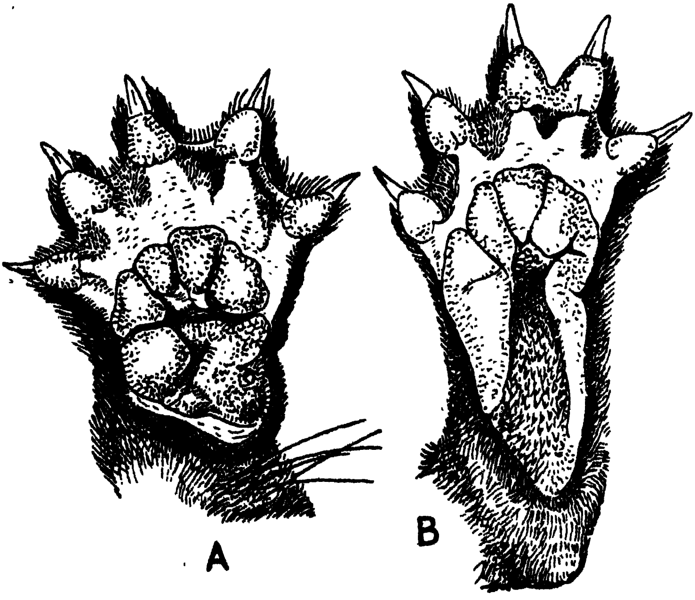
The genus *Paradoxurus*, including the species referred to *Paguma* and *Macrogalidia*, ranges from India and Ceylon to the Philippine Islands and Celebes. *Arctictis* extends from the eastern Himalayas to Borneo, and *Arctogalidia*, with the same eastern limit, reaches Assam. *Nandinia*, on the contrary, is restricted to the forests of tropical Africa.

The Feet of Paradoxurus.

Of this genus I have examined examples of the three species *P. larvatus* from Szechuen, *P. niger* from India, and *P. hermaphroditus* from Singapore. According to Gray's nomenclature, which there is a tendency at the present time to revive, *larvatus* should be referred to the genus *Paguma*; but in this paper I propose, without prejudice, to follow Blanford and most modern authors in regarding *Paguma* as a synonym of *Paradoxurus*.

The fore foot of *P. larvatus* is broad; the digits are capable of considerable distension and are webbed up to the proximal ends of the digital pads; the underside of the webs is smooth, save for the presence of four patches of short hair near the distal margin of each. The pollex is well developed and lies close to the second digit. The plantar pad is large and wide owing to the size of its pollical lobe, which approximately equals in dimensions any one of the three main lobes corresponding to the intervals between the four principal digits. The lobes are well defined by grooves. The double carpal pad, separated by a deep naked crease from the plantar pad, is at least as wide and long as the latter including its pollical lobe. The external lobe of the carpal pad is about twice as large as the internal and is defined from it by a deep groove. These carpal pads occupy practically the whole width of the paw behind the plantar pad and, like the latter and the digital pads, are covered with coarsely granular or scale-like integument.

Text-figure 1.



Paradoxurus larvatus.

A. Left fore foot, digits fully stretched.
B. Left hind foot, „ „

The claws are protected by rudimentary skin-lobes and are retractile in the sense that the terminal phalanx can be drawn back so as to lie along the outer side of the penultimate phalanx as in most of the Viverridæ and the Felidæ.

The hind foot resembles the fore foot in its main features, but is narrower and the digital pads of the third and fourth digits are united at the base; behind their point of junction there is a small triangular patch of short hair. Similar patches of hair are present on the underside of the proximal half of the webs, as in the fore foot. The hallux is shorter than the pollex, but the hallucal lobe is large and adds considerably to the width of the plantar pad, the elements of which are well defined. Behind the plantar pad the greater part of the underside of the metatarsus is naked; the naked area, narrowing posteriorly or proximally, reaches to within about half an inch of the heel, which is covered with hair. This naked area exhibits a median depression which is narrower distally close to the plantar pad than proximally towards the heel, and is bounded at the sides nearly throughout its length by two thick ridges of integument, the metatarsal pads. The external of these, narrower but a little longer than the internal, is continuous distally with the external lateral lobe of the plantar pad; the internal is similarly continuous with the hallucal lobe of that pad. In the specimen here described, the depression between these pads or ridges is thickly covered with horny sub-spiniform papillæ.

The feet of *Paradoxurus hermaphroditus* and *P. niger* show no differences of moment from those of *P. larvatus*. The underside of the webs, however, is naked; and the example of *P. niger* examined exhibited no sharp horny papillæ in the depression between the metatarsal pads of the hind foot.

The Feet of Arctictis.

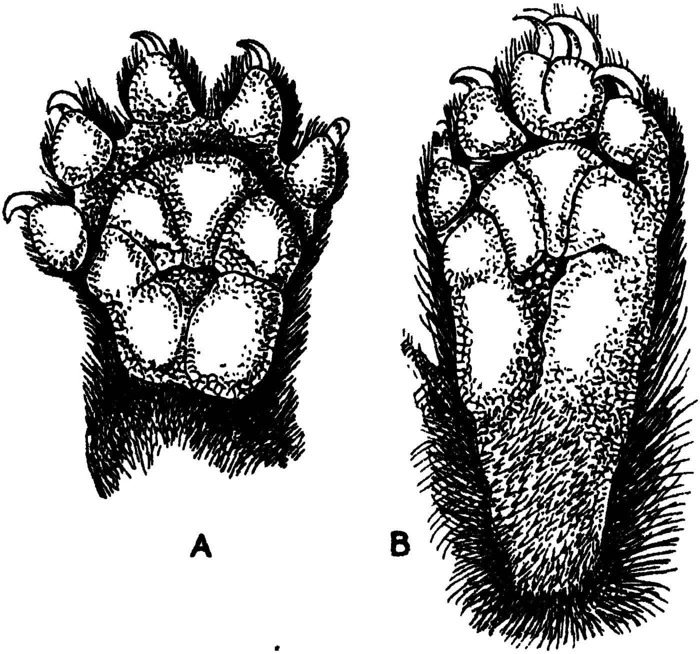
The fore foot resembles in all essential respects that of *Paradoxurus larvatus*, but the web connecting the digits is naked beneath, and the two elements of the carpal pad are not so sharply defined from one another and from the plantar pad.

The hind foot is also like that of *Paradoxurus* in most respects, particularly, be it noted, in the fusion of the digital pads of the third and fourth digits proximally. Here also there is no hair on the underside of the interdigital webs, the division between the plantar and metatarsal pads is ill-defined, and the metatarsal area itself is not sharply differentiated into a median depression and lateral elongated pads. On the contrary, it is comparatively flat and the naked area extends right back to the heel. In one example, a full-sized but young male, the skin of the underside of the heel is covered with a mat of horny, pointed papillæ. No such mat, however, is present on the heel of a young female, and, judging from the skins in the British Museum, its development is variable, the sculpturing being sometimes papillate, sometimes squamous.

The claws are sharp, strongly curved, and retractile, but are unguarded by lobes of skin.

In the nakedness of the heel, *Arctictis*, as has been noticed by Mivart and others, differs from all other genera of Paradoxurines.

Text-figure 2.



Arctictis binturong.

A. Left fore foot, digits partially stretched.
B. Left hind foot, digits not stretched.

This may be an adaptation to a more thoroughly arboreal life—a conclusion supported by the prehensile power of the tail [*]; but I cannot find any record of the proximal fusion of the pads of the third and fourth digits. This character is very suggestive of affinity between *Arctictis* and *Paradoxurus*.

The Feet of Arctogalidia.

The feet of an example from Sarawak resemble in a general way those of *Paradoxurus*, but differ in one or two interesting particulars, especially in being longer, narrower, and less fully webbed. In the fore paw the digital and plantar pads are well

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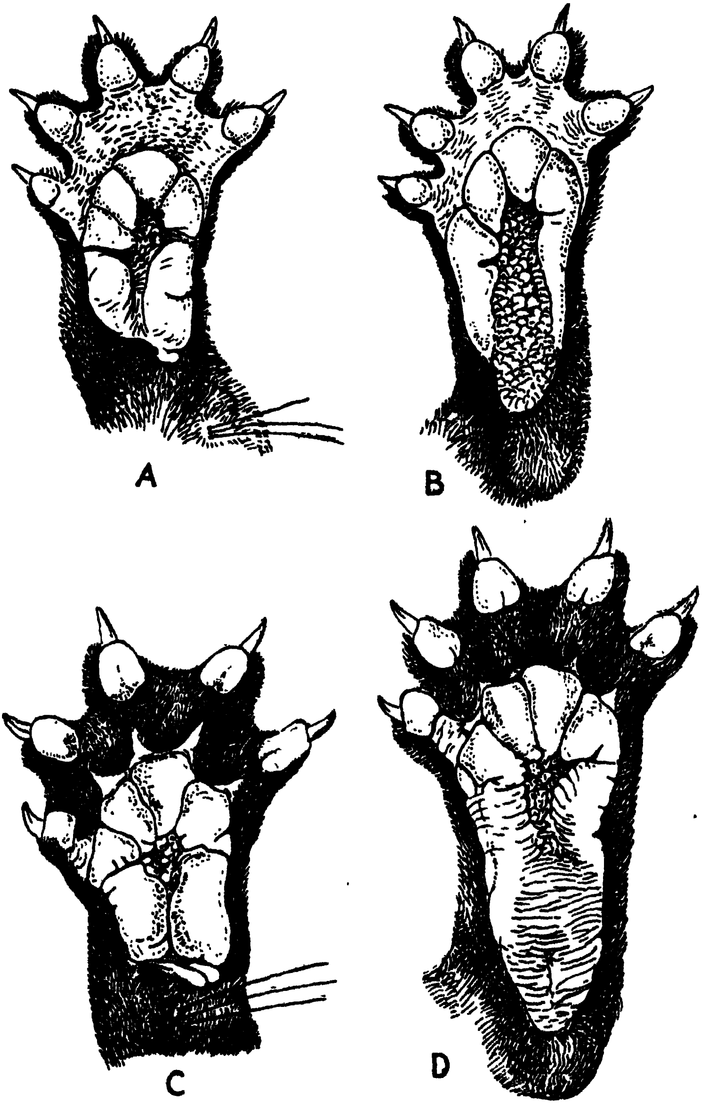
[*] About half an inch of the end of the tail was naked and formed a conical point to that organ calculated to enhance its grasping capacity.

Text-figure 3.



Arctogalidia, from Sarawak.

A. Left fore foot, digits fully stretched.
B. Left hind foot, ,, ,,

Nandinia binotata.

C. Left fore foot, digits fully stretched.
D. Left hind foot, ,, ,,

developed in the matter of thickness, but are covered with smooth integument, and the four lobes of the plantar pad are separated by shallow grooves and are therefore somewhat ill-defined. The area between the digital and plantar pads is quite hairless and the edge of the webbing between the 1st and 2nd, 2nd and 3rd, and 4th and 5th digits, and to a less degree that between the 3rd and 4th digits, is more deeply emarginate than in *Paradoxurus*. The anterior and lateral borders of the plantar pad form a narrower curve than in that genus, the pollical lobe especially being set farther back with reference to the median lobe. The carpal pads are much longer and narrower, but are as wide throughout as the plantar pad. The claws are short and strongly curved and not protected by skin-lobes.

The hind foot differs from that of *Paradoxurus* in characters similar to those mentioned in connection with the fore foot, but one additional difference to be noticed is that the pads of the 3rd and 4th digits are not fused but are separated by a measurable extent of webbing. The naked area on the metatarsus is of about the same extent as in *Paradoxurus*, the heel being thickly hairy as in that genus; and in the skins examined the area between the two smooth lateral ridges, or metatarsal pads, is covered with coarsely squamous integument, the pads themselves, like the plantar and digital pads, being smooth as in the fore foot.

The Feet of Nandinia.

The feet of this genus have only been briefly described previously, so far as I have ascertained. Mivart (P. Z. S. 1882, p. 170) says that the tarsus and metatarsus are "about as bald as in *Paradoxurus*," which is true; but Lydekker's statement that the tarsus is partially bald as in *Hemigalus* is not in accord with the facts (Lloyd's Nat. Hist.: Cats etc., p. 228, 1896).

The fore foot resembles that of *Paradoxurus larvatus* in the development of the webs at least to the proximal ends of the digital pads, in the extent to which the toes are capable of separation, and in the confluence of the plantar and carpal pads to form a single mass, of which the component elements are defined merely by grooves. These pads, however, are longer as compared with their width than in *Paradoxurus*, and in the more backward position of the pollical lobe and the closer curvature of the distal margin of the plantar pad resemblance may be seen to *Arctogalidia*. A very narrow area of skin, sometimes giving off short streaks towards the digital pads of the 2nd, 3rd, 4th, and 5th digits, is naked, but otherwise the whole of the area between the plantar and digital pads is thickly covered with velvety hair as in *Genetta* and *Viverra*. In this respect the feet differ from those of *Paradoxurus* *, *Arctictis*, and *Arctogalidia*. The underside of the pollex is, moreover, quite naked, the digital pad of this digit, which is considerably shorter than in *Paradoxurus* and a little shorter than in *Arctogalidia*, being connected with the pollical lobe of the plantar pad by a bare strip of integument.

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* Hodgson, however, described this area in *Paradoxurus lanigerus* as hairy; but whether the hair was developed to the extent seen in *Nandinia* or in *Paradoxurus larvatus* does not appear.

The claws are retractile but are not guarded by small skin-lobes as in *Genetta*. The pads are in the main quite smooth, but the central depression behind the plantar pad is somewhat coarsely sculptured.

The hind foot, so far as the webbing and the structure of the plantar pad are concerned, resembles and differs from that of the other genera described in this paper in the same respects as those mentioned in connection with the fore foot. The digital pads, however, of the third and fourth digits are widely separated, even more so than in *Arctogalidia*, and resemble in this respect the homologous pads of *Genetta* and other Viverrines. The whole of the posterior area of the naked metatarsal space is coarsely ridged transversely, and this ridging is replaced in the elongated depression behind the plantar pad by coarse polygonal sculpturing. This depression is bounded on each side by a thick, elongated, metatarsal pad, sculptured internally, but these pads are not so long as in *Paradoxurus* and *Arctogalidia*[*].

The characters of the feet of the four genera of Paradoxurines above described may be systematically epitomised as follows:—

a. Pads of 3rd and 4th digits of hind foot proximally united in the middle line; fore paws broad, their plantar and carpal pads combined only a little longer than wide; pads of fore and hind feet with coarse tessellated sculpturing.
  a′. Sole of hind foot not naked to heel . . . . *Paradoxurus.*
  b′. Sole of hind foot naked to heel . .. . *Arctictis.*
b. Pads of 3rd and 4th digits of hind foot separated; fore paws narrower, their plantar and carpal pads combined much longer than wide; pads of fore and hind feet smooth or nearly so; [heel of hind foot hairy as in *Paradoxurus*].
  a^2. Area between plantar and digital pads smooth ... ... *Arctogalidia.*
  b^2. Area between plantar and digital pads, except of digit 1, thickly hairy ... . *Nandinia.*

The tessellated sculpturing of the pads observed in *Arctictis* and the species of *Paradoxurus* examined must be verified for other species of the latter genus, before it can be definitely regarded as a generic feature. The fusion of the pads of the 3rd and 4th digits of the hind feet in these two genera—obviously a specialised feature—may be regarded as evidence of affinity between them; but the separation of these same pads in *Nandinia* and *Arctogalidia* is a case of the mutual inheritance of a primitive character, and cannot be considered as evidence of relationship.

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[*] From the foregoing account of the hind feet of *Paradoxurus*, *Arctogalidia*, and *Nandinia* it will be seen that Mivart's description of the tarsus as "half-bald" in these genera is untrue, since by the term tarsus he meant the whole area between the plantar pad and the heel (P. Z. S. 1892, p. 206). He also included *Hemigalus* (*Hemigalea*) in the category of genera with "half bald" tarsus, although his own figure of the hind foot of this genus (*op. cit.* p. 166) shows correctly that the greater part of the sole behind the plantar pad is covered with hair.

Comparison between the Paradoxurine and Viverrine types of feet.

The feet of the Paradoxurine genera above described, and those of the Viverrine genera described in my previous paper (P. Z. S. 1915, pp. 132–140), may be briefly compared as follows:—

Viverrinæ.—The pollical and hallucal elements of the plantar pads are either suppressed or small, and when present lie altogether behind the internal lateral lobe of the plantar pads so as to contribute nothing to the width of the latter. The carpal pads whether single or double are much shorter and narrower than the plantar pad, occupy only a small part of the underside of the carpo-metacarpal area, and are separated from the plantar pad by a tolerably long space, of which the median portion at least is covered with hair. The underside of the metatarsus is for the most part covered with hair; when the metatarsal pads persist, they are reduced to a small bilobed pad some distance away from the plantar pad (*Civettictis*), or to two narrow median ridges of integument in contact throughout the greater part of their length, slightly separated towards the heel and more strongly divergent inferiorly where they extend to right and left to meet the postero-lateral angles of the plantar pad, leaving a hairy space between (*Genetta*).

Paradoxurinæ.—The pollical and hallucal elements of the plantar pads are large and comparable in size to the three remaining lobes of this pad individually, thus adding considerably to its width. The carpal pads are long and wide, occupy nearly the whole of the width of the underside of the carpo-metacarpal area, and conjointly equal or approximately equal the plantar pad in area; they are defined from it by a transverse groove which expands mesially into a depression, but this depression is never hairy. The metatarsal area is naked throughout the greater part of its length and width; when the metatarsal pads are retained they form two thick ridges of integument separated by a wide depressed area.

From this it is clear that the differences between the feet of these two groups are considerable. The differences in the case of the Viverrinæ have arisen, as I have already pointed out (P. Z. S. 1915, p. 139), by the suppression or reduction in size of the pollical and hallucal elements of the plantar pads, by the reduction in size of the carpal pads, the growth of hair between them and the plantar pad, and by the suppression or reduction in size of the metatarsal pads and their replacement by normal hairy integument. In the case of *Genetta*, which of all the Viverrinæ has the least specialised feet, it is clear that the two juxtaposed narrow ridges of skin extending along the middle line of the metatarsus are the homologues of the two thick ridges or pads, separated by a median depression, in *Paradoxurus* or *Arctogalidia*.

There is one other genus of Viverridæ which calls for attention here because its feet belong to the Paradoxurine type, though they differ in certain details from the feet of the genera to which that term is here restricted. This is the otter-like amphibious Civet *Cynogale*, which Gray first of all made the type of a special subfamily, afterwards raising it to family rank on characters held by Mivart to be trivial for that purpose. Mivart regarded *Cynogale* as an aberrant genus of his subfamily Viverrinæ, which embraced the Civets, Genets, Linsangs, Paradoxures, and others. The gland, however, was unknown both to Gray and Mivart. By this organ, as I have recently shown *, as well as by the structure of the muzzle and of the rhinarium, *Cynogale* differs considerably from the genera both of the Viverrine and Paradoxurine sections of Viverridæ, and cannot be included in either, as I define them, without unduly disturbing their homogeneity. In classifying this genus, therefore, I revert to Gray's original idea and regard it as the representative of a special subfamily, Cynogalinæ.

The Rhinarium and Vibrissæ of Paradoxurines.

In *Paradoxurus larvatus* the rhinarium is large and prominent. Viewed from the front its upper edge is markedly biconvex owing to the depth of the median groove and the curvature of the lateral angles. This groove extends uninterruptedly from a point close to the posterior border of the upper surface, over the anterior surface, where it is very deep, down to the edge of the lip in the middle line. The infranarial portion is large and extends laterally beyond the nostrils, where it curls up and narrowly borders them externally throughout their length on the upper side. Its inferior edge is horizontal with rounded angles. Just beneath the narial orifice in front, this infranarial portion is marked with a curved depression which runs downwards and inwards towards the middle line. This groove appears to correspond to the obliquely inclined infranarial edge of the rhinarium in *Canis* and *Felis*, the area external to the groove being covered with hair in those genera and other members of the families to which they belong.

Viewed from above, the convexity of the anterior edge is interrupted by a deep median angular notch—smaller in the young—and its posterior edge is concave. The narial slits converge inwards and backwards and are bordered externally by the narrow naked strip which is continuous in front with the superolateral angles of the large infranarial area. As a result of the backward and inward inclination of the narial slits, the upper field of the rhinarium is considerably wider in front than behind. Finally, it may be added, the hairy portion of the upper lip below the rhinarium is only about half the height of the anterior surface of the rhinarium itself.

Comparing the rhinarium of *Paradoxurus* with those of the

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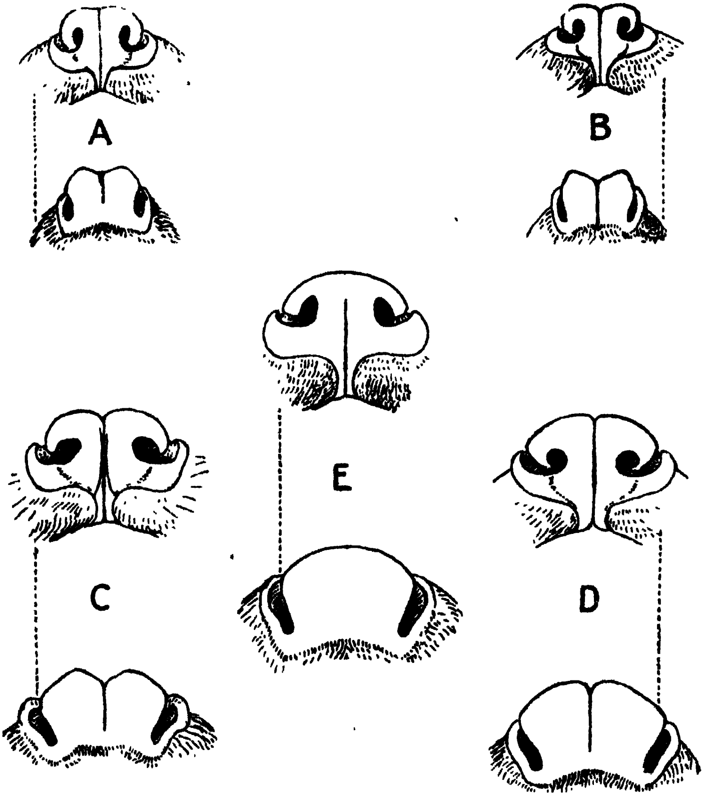
* Ann. Mag. Nat. Hist. (8) xv. pp. 351-360, 1915.

Viverrinæ described in my previous paper, it clearly resembles most closely that of *Viverra zibetha*, but its anterior and upper surfaces are much more deeply grooved, its superior angles on each side of the median notch are more prominent, and its upper surface is more markedly biconvex.

In *P. hermaphroditus* the rhinarium is like that of *P. larvatus* in all essential respects.

Text-figure 4.



Rhinarium, seen from the front and above, of A. *Nandinia*; B. *Arctogalidia*; C. *Paradoxurus larvatus*; D. *Arctictis*; E. *Civettictis*.

The rhinarium of *Arctogalidia* from the anterior aspect closely resembles that of *Paradoxurus*, but is narrower as compared with its height, and the lower edge of the infranarial portion slopes more obliquely upwards. Viewed from above, the median notch is wider and somewhat deeper, and the angles that define it are farther from the middle line and nearer the narial slits. These slits, moreover, are subparallel and only slightly convergent posteriorly, so that the upper surface of the rhinarium is only a little narrower behind than in front.

In *Nandinia* the rhinarium, seen from the front, is a little narrower and higher than in *Arctogalidia*, its upper edge is less markedly biconvex, owing to the sulcus being shallower. The upper surface has a shallower anterior notch, and is a little longer as compared with its width than in *Arctogalidia* and is quite as wide behind as in front.

The rhinarium of *Arctictis* differs from those of the other Paradoxurine genera here described in one or two points. The median groove extends over the upper surface, but is sunk in a much shallower depression. Hence the superior margin of the anterior surface is not markedly biconvex, but is fairly evenly convex from side to side, with only a small and shallow median notch. Seen from above, this margin is similarly convex from side to side, with a small median notch. The infranarial portion in front is shallower and has a more evenly rounded inferior border, and, when seen from above, the narial slits converge posteriorly as in *Paradoxurus*.

In my description of the rhinaria of the Viverrine genera *Viverra*, *Civettictis*, etc., I said:—“It is impossible to affirm the existence of any absolute difference between the rhinaria of the Viverrinæ collectively and of the Paradoxurinæ.” Confirmation of this is supplied by a study of this organ in the Paradoxurinæ; for, although the rhinarium of *Paradoxurus*, *Arctogalidia*, and *Nandinia* differs from that of the Viverrinæ in being very deeply sulcate above and in front, the rhinarium of *Arctictis*, a genus in most particulars the least Viverrine of all the Paradoxurinæ, is much less deeply and widely sulcate, its supero-anterior margin being evenly convex from side, to side with a quite small median notch. The convex curvature of this border recalls that of the rhinarium of the African Civet (*Civettictis*), although the median groove of the rhinarium is deeper both above and in front than in that genus. On the other hand, the rhinarium of the large Indian Civet (*Viverra zibetha*), with its upper surface biconvex, is more like the rhinarium of *Paradoxurus* than is the rhinarium of *Arctictis*. In the shape of this organ, therefore, the genera of Viverrinæ and Paradoxurinæ intergrade.

The facial vibrissæ may be briefly dismissed. The tufts are without exception normal in number, the mystacials in particular being long and rigid. Of the two genal tufts on each side, the inferior is situated in a line with the corner of the mouth and the superior a little higher up and posterior to it. The least developed is the interramal, but it is always present and not far behind the mandibular symphysis.

The Ear of Paradoxurines and Viverrines.

There appears to be no accepted terminology for the cartilaginous ridges which strengthen and support the pinna of the ear in mammals, and by interlocking help to close the meatus when it is capable of being closed. Mivart described the pinna of the Common Cat ('The Cat,' pp. 295-296, 1881) and of the Genet (P. Z. S. 1892, p. 51, fig. 12), adopting for the several parts names originally applied to the human ear. An entirely different nomenclature was, however, proposed by Boas in 1912 ('Ohrknorpel und äusseres ohr der Säugetiere,' Kopenhagen). In the following account I have attempted to show the correspondence between these two systems and have, in the main, followed that of Mivart as being more familiar and more intelligible, without wishing thereby to cast any reflection upon the excellence of Boas' work.

In *Paradoxurus larvatus* the cartilaginous ridges, with their intervening fossæ, which strengthen the lower portion of the pinna round the auditory meatus, resemble those of the Cat and Genet in essential features. Two ridges run obliquely upwards and forwards in front of the inferior orifice of the meatus (*aditus inferior* of Boas). The outer of these, the *posteron 4* of Boas, carries a low elevation called the *tragus* by Mivart. The inner, the *anteron 6* of Boas, has a sinuous edge and runs higher up the front of the ear than the outer or tragus-bearing ridge. This inner ridge is called the post-tragus by Mivart in the case of the Cat, but in his figure of the Genet's ear it is marked tragus. Two ridges similarly run obliquely upwards and backwards from the inferior orifice of the meatus. The outer of these, the *posteron 6* of Boas, is produced inferiorly into a large angular process, the *antitragus* of Mivart, which fits into the lower part of the fossa between the two anterior ridges when the ear is closed. Above and within the outer ridge lies the inner of the two posterior ridges, which is much softer and less well developed than the others and shows a small swelling near its lower end. This ridge, an integumental non-cartilaginous structure, was not given a special name by Mivart, and was merely described as a "weiche Falte" by Boas. Nevertheless it appears to be a constant feature in the ears, at all events, of the Canidæ, Felidæ, and Viverridæ.

The four ridges above described, with their intervening fossæ, form the anterior and posterior walls of the deep and spacious fossa lying above the auditory meatus. This large fossa is defined above by a transverse cartilaginous ridge, the *plica principalis* of Boas and the *supratragus* of Mivart, the anterior end of which is overlapped by the inner of the two anterior ridges. Towards the middle of the ear it exhibits a marked swelling, and behind this the ridge gradually fades away towards the inner side of the inner of the two posterior ridges *.

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* The cartilaginous thickening in the ear of the Carnivores, named *posteron 4* by Boas and *tragus* by Mivart, seems certainly to be the homologue of the "tragus" in the human ear. But the thickening named "antitragus" by Mivart and *posteron 6* by Boas is not, according to this latter author, the exact homologue of the human antitragus. This well-developed structure in man is part of another cartilaginous ridge, the *posteron 5* of Boas, which is at most feebly developed in the Carnivores, being merely represented by a weak ridge lying below and on the outer

The posterior margin of the ear, nearly in a line with the supratragus, is doubled to form a definite pocket, called the "pouch" by Mivart and the "Körbchen" or "Tasche" by Boas. For this I have proposed the name "*bursa*." The anterior flap of this is continuous above and below with the rim of the pinna, and its edge is deeply, widely, and angularly emarginate. The posterior flap, on the contrary, is semilunar with a continuously convex edge, the upper and lower ends of which are attached behind the rim of the pinna, as in the Genet and, I believe, all species of *Felis*.

Comparing the ear of *Paradoxurus larvatus* with that of the three genera of Viverrines—*Genetta*, *Viverricula*, and *Civettictis*—the following points may be noticed. In *Genetta dongolana* (Somaliland) the bursa is formed as in *P. larvatus*, except that the emargination of the anterior flap is nearly rectangular in the former and obtusely angular in the latter. In *Civettictis civetta* and *Viverricula malaccensis*, on the other hand, the anterior flap is less deeply and more widely emarginate and the convex edge of the posterior flap is continuous above and below with the rim of the pinna, instead of rising behind it. Also in these two the inner of the two anterior ridges carries a much larger process overhanging the anterior end of the supratragus (antihelix or plica principalis) than is to be seen in *Genetta dongolana* and *P. larvatus*.

In *Genetta dongolana* and *rubiginosa* the tragus is more markedly bilobed and the antitragus provided with a better developed external ridge, giving rise to the "double" condition described by Mivart in *G. tigrina*, than in *P. larvatus*. This external ridge is very well formed in *Viverricula*, but is not larger in *Civettictis* than in *Paradoxurus larvatus*.

Apart, however, from the bursa, the ears of the four species are very much alike, and the recorded differences in the exact shape of the ridges must be tested in the case of other species of the genera before, in my opinion, it will be safe to attach systematic importance to them. They may be due merely to individual variation.

The ear of *Paradoxurus hermaphroditus* resembles that of *P. larvatus* except that the anterior flap of the bursa is more deeply and roundly emarginate and its angles, especially the inferior angle, are more produced.

I did not examine in a fresh state the ears of *Arctictis*. The only point of importance that could be made out on a dry skin was the presence of the bursa and its resemblance to that of *Paradoxurus larvatus*, in the origin of the upper end of the

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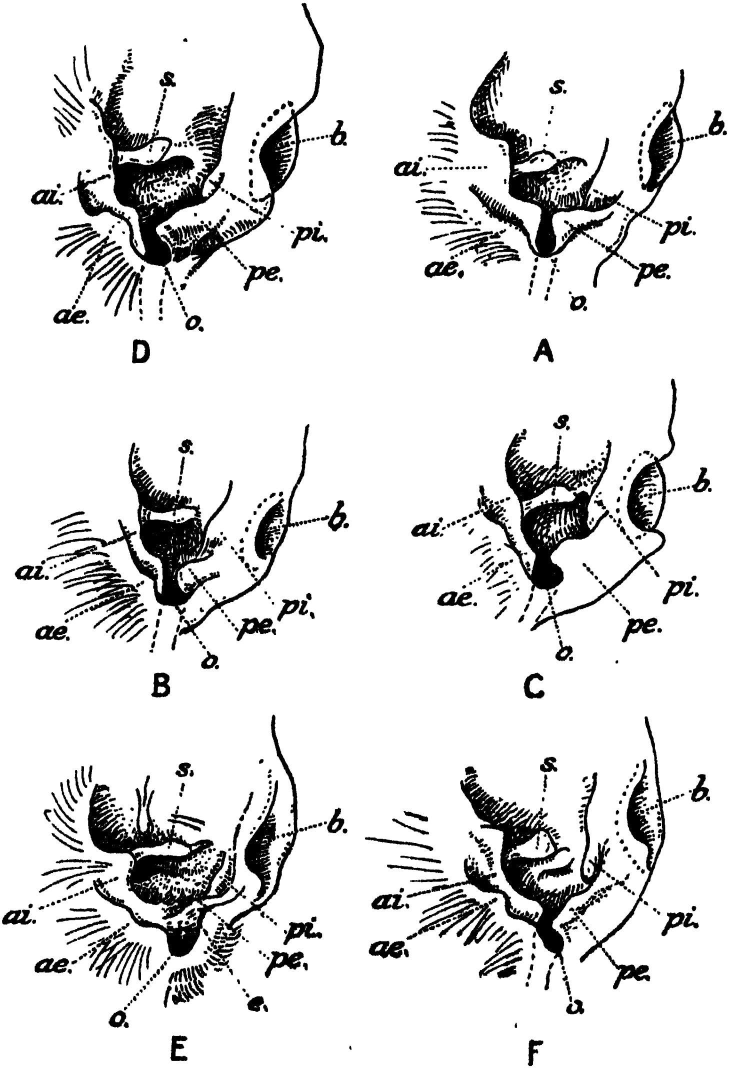
side of the so-called antitragus. Mivart recorded the two ridges as a "double antitragus," a quite intelligible view. On the other hand, Mivart does not seem to have detected that the ridge he named the *post-tragus* (=*anteron 6* of Boas) corresponds to the basal portion of the ascending helix in man, and that the *supra-tragus* (=*plica principalis* of Boas) is the homologue of part of the *antihelix* of human anatomists.

Text-figure 5.



Base of pinna of left ear of A. *Nandinia*; B. *Arctogalidia*; C. *Paradoxurus hermaphroditus*; D. *P. larvatus*; E. *Viverricula malaccensis*; F. *Civettictis civetta*.

b., bursa; *o.*, inferior orifice of meatus; *s.*, superior ridge (=*supratragus* of Mivart); *ae.*, external of the two anterior ridges (=*tragus* of Mivart); *ai.*, internal of the two anterior ridges (=*post-tragus* of Mivart); *pe.*, external of the two posterior ridges (=*antitragus* of Mivart); *pi.*, internal of the two posterior ridges; *e*, supplementary ridge outside *pe.* in *Viverricula*.

posterior flap from the back of the pinna and the continuity of the rim of the pinna with the upper end of the anterior flap. This flap, however, is much more widely and less deeply emarginate than in *P. larvatus*.

In *Arctogalidia* the cartilaginous ridges of the ear resemble in a general way those of *Paradoxurus larvatus*, but there is a distinct though small ridge on the outer side of the antitragus. The bursa, however, differs in one or two points. The margin of its anterior rim is not so deeply or abruptly excised, and its posterior rim is continuous above with the rim of the ear and does not arise behind it as in that genus. Hence the orifice of the bursa is more closed, and its posterior wall does not form a flap freely movable on its base of attachment. In other words, the bursa in *Arctogalidia* is more like that of *Viverricula malaccensis* and *Civettictis civetta* than of *Paradoxurus larvatus* and *Genetta*.

In *Nandinia binotata* the inner of the two anterior cartilaginous ridges differs from that of *Paradoxurus larvatus* and of *Arctogalidia* in the larger size and angular shape of its two processes. As in *Arctogalidia*, the antitragus carries an external ridge. The bursa resembles that of *Paradoxurus*, *Arctictis*, and *Genetta* in the origin of its posterior flap from the back of the pinna, but the angular excision of its anterior flap is shallower than in *Paradoxurus*, but deeper than in *Arctictis*.

From the foregoing account it will, I think, be clear that it is impossible to make use of the ears in differentiating the Viverrinæ from the Paradoxurinæ. Nevertheless, within the limits of these two subfamilies the structure of these organs, and especially of the bursa, will probably be found useful for distinguishing genera.

I am quite unable to surmise what meaning is to be attached to the variation in the structure of the bursa, by which the genera above discussed may be grouped as follows:—

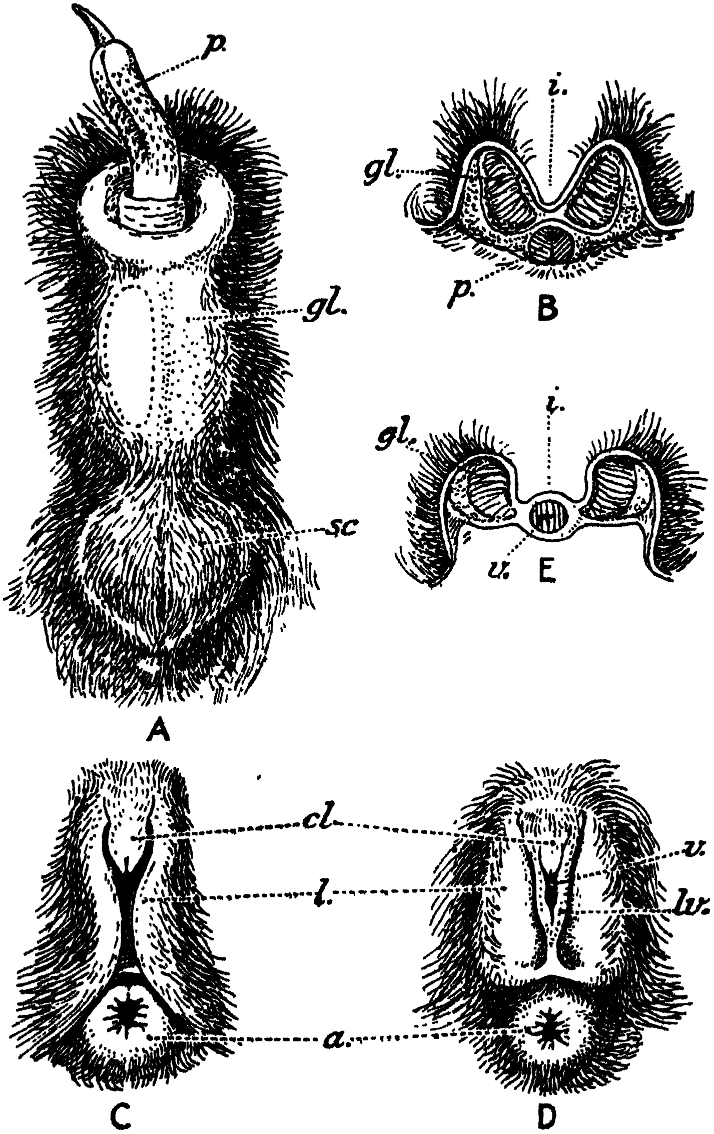
a. Posterior flap of bursa arising above behind the rim of the pinna .... *Genetta*, *Paradoxurus*, *Arctictis*, *Nandinia*.
b. Posterior flap of bursa continuous above with the rim of the pinna .... *Viverricula*, *Civettictis*, *Arctogalidia*.

Since the condition of the bursa found in Canidæ, Felidæ, and some of the Arctoid Carnivora is the same as that described under heading *a*, this condition is probably the primitive one. Probably, also, the condition described under heading *b* is the beginning of the suppression of the bursa, a process which is completed in some Æluroid and some Arctoid Carnivores.

The Perfume-gland and External Genitalia of Paradoxurus.

One of the earliest descriptions of the gland and genitalia of *Paradoxurus* was published under the name *Platychista pallasii* (=*Paradoxurus hermaphroditus*) by Otto (Nova Acta Acad. Leop.-Car. xvii. p. 1089, pl. lxxiii, 1835). Except in the structure of

Text-figure 6.



Paradoxurus larvatus,

A. Gland and external genitalia of male. *gl.*, glandular area with the position of the right gland dotted in, the median depression not represented; *p.*, glans penis; *sc.*, scrotum.

(*Continued at foot of next page.*)

the penis and its precise relations to the gland, the figure accompanying the description agrees with my own observations.

A year later Hodgson (Asiatic Res. xix. p. 77, 1836) described the perfume-glands of three species referred to *Paradoxurus*, namely, *hirsutus*, *nipalensis*, and *lanigerus*. According to Blanford the name *hirsutus* was applied to the two species now known as *niger* and *hermaphroditus*; *nipalensis* is a synonym of *grayi*, but the species named *lanigerus* can only be assigned to the genus with hesitation. By the system of classification now in use, *niger* and *hermaphroditus* belong to the genus *Paradoxurus* and *grayi* to the genus *Paguma*; and I do not doubt that *lanigerus* is also a *Paguma*.

Hodgson detected no difference between the glands of the species he examined; and although he examined both males and females, his description suggests that the glands in the two sexes are alike in their relations to the vulva and penis. This, however, is not the case, as will be explained, since the penis is situated at the anterior end of the naked glandular area and the vulva lies near its centre.

Mivart's description of the scent-glands as lying "beneath the surface of a valve-like antero-posteriorly directed cutaneous inflection, more or less naked, and situated between the penis and testes in the male and analogously in the female," conveys very little idea of their structure (P. Z. S. 1882, p. 163).

Turner's very brief description of the gland of *P. niger* (=*typus*) as an oval, flat, naked space at the base of the prepuce, although wanting in preciseness as to the situation of the gland, is accurate and intelligible (P. Z S. 1849, p. 25).

The main portion of the gland in the male consists of a pair of thickened ridges of skin or labia extending between the scrotum and the penis. These labia form the side-walls of a longitudinal fossa which is everywhere perfectly smooth; but the margin and outer surfaces of the labia are covered with long hair. The paired glandular thickening, which makes these labia, does not extend so far forwards as the penis, but a rim of thickened skin, naked internally, hairy externally, passes forwards in front of them and encircles the base of the penis like a collar. The narrow space between the collar and the penis is highly glandular,

Description of text-figure 6, *continued.*

B. Transverse section of the glandular area of the same; *gl.*, gland of right side; *i.*, glandular space bordered by the two labia; *p.*, penis.

C. Gland and external genitalia of female. *cl.*, clitoris; *l.*, left labium of gland folded over glandular area; *a.*, anus.

D. Same as fig. C, with labia of gland (*l.*) pulled apart to show vulva (*v.*) and narrow labia of vulva (*lv.*). *a.*, anus; *cl.*, clitoris.

E. Transverse section of same behind vulva. *gl.*, gland; *i.*, glandular space bounded by the two labia; *v.*, vagina.

the secretion having a repulsive odour. The secretion of the paired gland has a "mousy" smell and is poured over the naked skin of the fossa between the two labia. These labia are capable of being widely separated so that the glandular area may be flattened, but they are not closely applied and separated merely by a narrow *rima*, like the labia of the homologous gland in *Viverra* and *Genetta* *. The glans of the *penis* is long, flexible, subcylindrical, weakly grooved below, and beset with recurved horny papillæ. It ends in a styliform process.

The arrangement in the female is tolerably similar. The labia of the gland arise in front on each side of the clitoris and pass backwards to the anal area. They are naked on the inner side, but hairy externally as in the male. Anteriorly they lie outside the hairy labia of the vulva, which lies just behind the clitoris; and the labia of the vulva unite posteriorly and form a low ridge of naked integument which runs along the bottom of the space between the labia of the gland and spreads to right and left, forming a short transverse ridge in front of the anal area. The labia of the gland can be folded over the vulva and the naked glandular space behind the clitoris, exactly as in the male the corresponding labia can be folded over the glandular space behind the penis; but in the female these labia are not closely applied as they are in *Genetta* and *Viverra*.

The anal area in both sexes is tolerably large and naked as in *Genetta* and *Civettictis*, but the repulsive secretion of the anal glands is not retained by an annular ring of skin as in *Viverra zibetha*.

In male examples of *Paradoxurus niger* and *P. hermaphroditus* the glandular area closely resembles in its general features that of *P. larvatus* in consisting of a naked, elongated, tongue-shaped area of whitish glandular integument extending from the scrotum behind round the prepuce in front. But there is no thickened collar of skin round the penis and the labia of the gland are much less pronounced, so that when the thighs are separated the glandular surface forms no definite median fossa but is almost flat from side to side. When, however, the inner surfaces of the thighs are in their normal position and juxtaposed, the right and left halves of the glandular surface are brought into contact. The degree of development of these labia may prove to be a generic difference between *Paguma* and *Paradoxurus*. At all events, the conditions described hold good in the case of two species of each of the genera as recognised by Gray. The penis of *Paradoxurus niger*, judging from Turner's description (P. Z. S. 1849, p. 25), resembles that of *P. larvatus*, and the same applies to the penis of *P. hermaphroditus* that I examined.

In a half-grown female of *P. hermaphroditus* the glandular area consists of a nearly flat area of naked skin, without distinct labia. The vulva lies near its centre, and on each side of the vulva there extends backwards a shallow groove beset with a row of coarse pores. The anterior end of each groove reaches as far forwards as the corresponding end of the vulva, but the posterior end reaches considerably farther back, nearly to the hinder end of the area of naked skin. The low ridges between these posteriorly converging grooves and the vulva are scantily hairy, and constitute the labia of the latter orifice.

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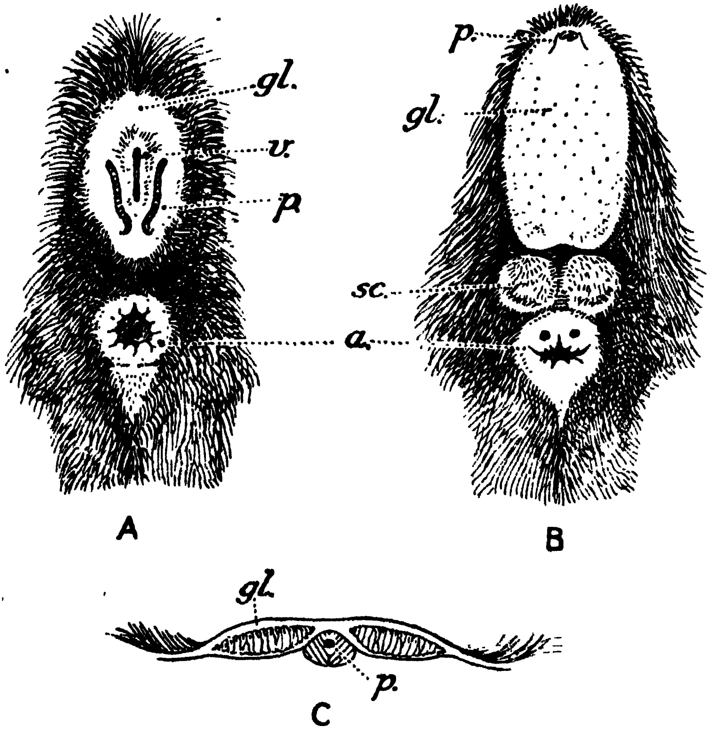
* The gland in a living example of *P. leucomystax* resembles apparently that of *P. larvatus*.

Text-figure 7.



Paradoxurus hermaphroditus.

A. Gland and external genitalia of half-grown female. *gl.*, anterior end of glandular area; *v.*, vulva, surrounded by short hairs; *p.*, row of secreting pores; *a.*, anus.

B. The same of adult male. *gl.*, glandular area flattened; *p.*, prepuce at its anterior end; *sc.*, scrotum; *a.*, anus, with orifices of anal glands.

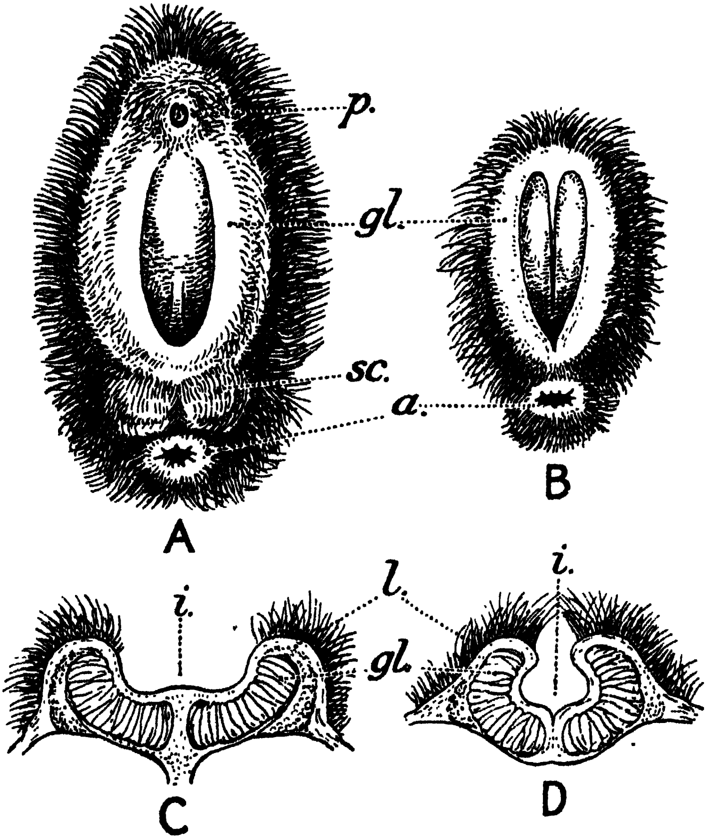
C. Transverse section of glandular area of male. *gl.*, right portion of gland; *p.*, penis.

This gland differs from that of the female *P. larvatus* in the absence of distinct labia, as in the case of the males of the two species.

The Perfume-gland and External Genitalia of Arctictis.

The gland of the male was first described by Cantor (J. A. S. Bengal, 1846, p. 192), and subsequently by Garrod (P. Z. S. 1873, p. 200). It resembles that of *Paradoxurus larvatus* in consisting of a pair of upstanding labia, hairy externally, smooth internally, extending from the scrotum up to the penis, and separated by

Text-figure 8.



Arctictis binturong.

A. Gland and external genitalia of male. *gl.*, glandular area showing labia and central depression; *p.*, prepuce. *sc.*, scrotum; *a.*, anus.

B. Gland of the female (vulva omitted); lettering as in A.

C & D. Transverse sections of the same with the labia of the gland partially distended and nearly in contact. *gl.*, gland of one side; *i.*, glandular space between the labia (*l.*).

a naked fossa which becomes gradually shallower towards the penis. There is no definite collar of skin round the prepuce but integument, resembling that of the free edge of the labia in being scantily covered with yellow hair, encircles that organ. The posterior end of the fossa is partially divided by a low membranous partition when the labia are not widely divaricated.

The penis, which I omitted to examine, was described by Garrod as follows: "The glans penis is conical and pointed, ¾ inch long, and presents round its base several small, dark brown, hard flattened papillæ about $\frac{1}{15}$ inch long." From this it may be inferred that the glans is shorter than in *Paradoxurus*, has no styliform termination, and is further distinguished by the restriction of the papillæ to its base, their smaller number and flattened, unspine-like shape.

The gland of the female does not appear to have been described. It is very like that of the male, consisting of a small longitudinal fossa, with an upstanding labium, hairy without and naked within, on each side of it. As in the male and in *Paradoxurus*, these labia, which converge anteriorly and posteriorly, are capable of being widely divaricated, but they are not tightly juxtaposed as is the case with the homologous labia of *Viverricula*, *Genetta*, etc. When only partially divaricated, the floor of the fossa rises into a low median ridge of skin. The vulva is situated in front of the glandular area, not near its centre as in *Paradoxurus*. The glandular area is thus wholly perineal as in the Viverrines.

The Perfume-gland and External Genitalia of Arctogalidia.

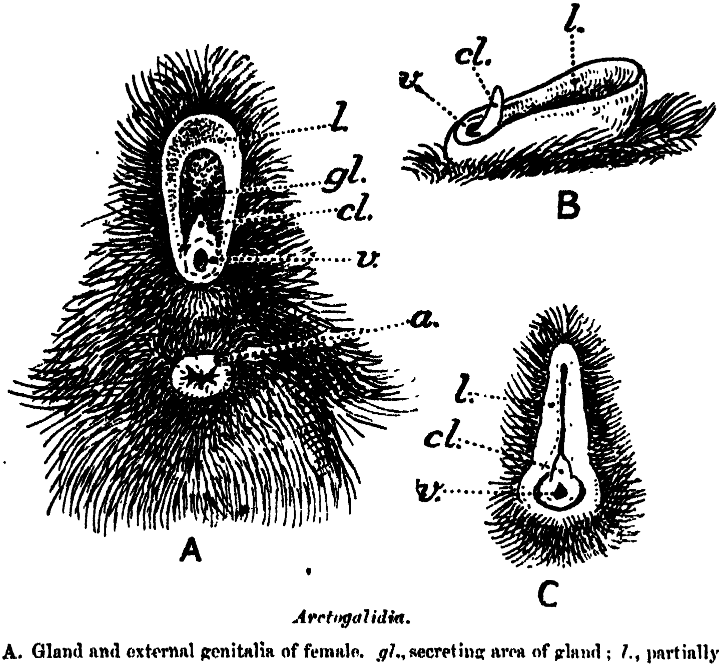
The gland in this genus does not appear to have been described. Temminck and S. Müller, as Mivart stated, are silent about it. Hence Mivart presumed the gland to be as in *Paradoxurus* (P. Z. S. 1882, p. 165). On the other hand Blanford (Mamm. Brit. India, p. 115, 1888) said: "there is no bald space in front of the scrotum or around the genital orifice; hence it is probable that the prescrotal glands, if they exist, are ill developed." What material Blanford had whereon to base this opinion does not appear; but the concluding sentence of the quotation suggests that the result of his examination, presumably of dried skins, was unsatisfactory. At all events his remarks do not justify Lydekker's statement that "there is no glandular tract in front of the scrotum" (Lloyd's Nat. Hist.: Cats. etc. p. 230, 1896).

I can say nothing about the gland in the male, but a female example identified as *A. leucotis*, from Sarawak, has a distinct though small naked glandular tract in front of the vulva; or rather, since the naked integument narrowly encircles the vulva behind, that orifice, preceded by a well-developed clitoris, may be described as situated at the posterior end of the glandular area. The area itself is antero-posteriorly elongated and is surrounded laterally and in front by an upstanding flap of quite naked skin capable of being flattened out externally and anteriorly, or folded over towards the middle line to form a pair of elongated labia in contact throughout their length in front of the clitoris and vulva.

The part of this naked area which appears to be specially active lies just in front of the clitoris.

Behind the vulva there is a moderately long hairy, non-glandular, perineal tract, so that the anus, situated in the centre of a small, normal naked space, is remote from the glandular area.

Text-figure 9.



Arctogalidia.

A. Gland and external genitalia of female. *gl.*, secreting area of gland; *l.*, partially distended upstanding labia surrounding it. *cl.*, clitoris; *v.*, vulva; *a.*, anus.

B. Lateral view of the same; lettering as in A.

C. Glandular area showing the labia folded in front of the clitoris; lettering as in A and B.

Since glands are present in both sexes of the genera of Paradoxurine Viverrids described in this paper, and are better developed in the males than in the females, it can hardly be doubted that the male of *Arctogalidia* is also provided with a gland; but it appears to me to be impossible to foretell whether the gland of the male will prove to be in front of the penis or behind it. Perhaps the balance of evidence is in favour of its being prepenial, instead of prescrotal as in *Paradoxurus* and others *.

However that may be, the gland of the female *Arctogalidia* differs from that of *Paradoxurus* in several respects. In *Arctogalidia* the principal secreting area is the depression in front of the clitoris, encircled by an upstanding flap of thin skin naked without and within and apparently not specially glandular. The right and left portions of this flap form two labia confluent in front and capable of being folded over the glandular depression, thus meeting *in front* of the clitoris and vulva. Between the vulva and the anus there is a tolerably long hairy perineal area. In the female *Paradoxurus* the labia are thick, glandular, and hairy externally. They are not confluent in front but arise separately at the sides of the clitoris, pass backwards on each side of the vulva and extend some distance behind it, almost reaching the anal area, being separated therefrom by a very short hairy non-glandular area. When folded over they meet in the middle line *behind* the clitoris.

The Perfume-gland and External Genitalia of Nandiniæ.

The gland of the male was described by Flower (P.Z.S. 1872, p. 684) as follows:—"*Nandinia* resembles many of its allies in possessing a ... cutaneous scent-gland in the form of a longitudinal median depression an inch in length, with tumid naked margins and looking very like a vulva, situated in the pubic region immediately in front of the short, conical retroverted hairy prepuce." This description is perfectly correct, but it unfortunately suggests similarity in position between this gland and that of the typical Paradoxurines.

Ten years later Mivart (P.Z.S. 1882, p. 170, note) made a similar mistake when he described the gland as "a bald patch, no doubt glandular, in the situation of the prescrotal glandular structure of *Genetta*." It is quite true that the gland in *Nandinia* is prescrotal, but it does not lie between the scrotum and the penis as in *Genetta*, but in front of the penis as Flower stated.

In 1900 Miss Carlsson (Zool. Jahrb. Syst. xiii. pp. 509 528) figured and described the gland of the female as a narrow area of naked skin situated in front of the vulva and ending anteriorly in a distinct pouch. This had been previously detected by Noack, who regarded the pouch as the functional homologue of the marsupial pouch (Zool. Garten, Frankfurt, xxvii, p. 79, 1886).

In a half-grown female *Nandinia* I found the glandular area exactly as described by Miss Carlsson, except that it was separated from the vulva by a narrow area covered with hair and had only an indistinct pouch at its anterior end. It consisted of an elliptical patch of pale naked skin, with the anterior rim slightly raised. Probably as age advanced, the pouch would have been developed and possibly the area would have extended backwards to join the naked skin surrounding the vulva. The skin overlying the gland was thin, and the secretion was brown in colour and strong in odour.

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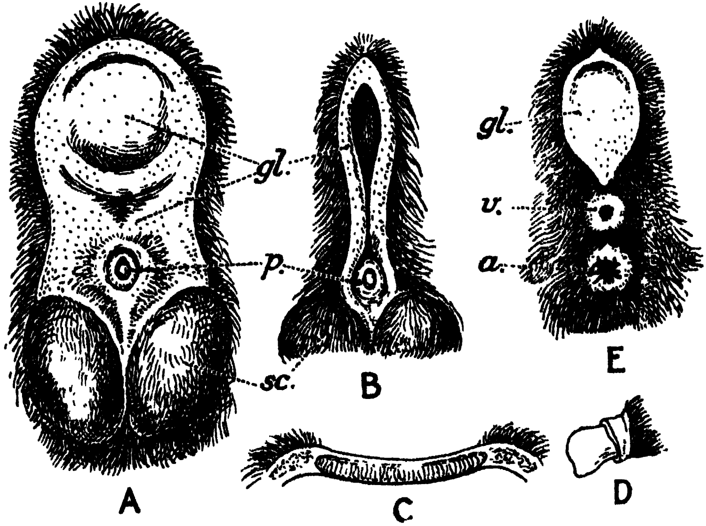
* If this proves to be so, a good case might be made out for severing *Nandinia* and *Arctogalidia* from the Paradoxurinæ as a separate subfamily Nandiniinæ.

Text-figure 10.



Nandinia binotata.

A. Gland and external genitalia of adult male. *gl.*, glandular area flattened; *p.*, prepuce surrounded by short hair; *sc.*, scrotum concealing anus.

B. The same with labia of gland folded in front of prepuce; lettering as in A.

C. Transverse section of gland in front of penis.

D. Glans penis, its dorsal side uppermost.

E. Gland and external genitalia of young female. *gl.*, glandular area; *v.*, vulva; *a.*, anus.

In the adult male the naked glandular area extends from the scrotum a long way in advance of the penis, which is situated near its posterior end, only a little in advance of the scrotum. Close to the penis on each side there are some hairs, sometimes forming a definite crest, sometimes more numerous and less regularly arranged. Sometimes there are also a few hairs right in front of that organ, but for the rest of the area it is quite smooth. The anterior half of the area expands and forms, when the gland is flattened out by the separation of the thighs, a shallow subcircular depression with tumid margins; but when the thighs are juxtaposed the right and left halves of the area approach, or nearly meet, across the middle line, being separated by a moderately deep fossa the width of which depends upon the degree of approximation of the right and left halves of the area. When its margins meet in front of the penis, these present the appearance, described by Flower, of two naked ridges of skin running forwards from the penis.

In longitudinal and transverse sections the gland is seen to consist of a comparatively thin layer of dermal cells, of tolerably uniform thickness transversely but gradually increasing in thickness from behind forwards. The secreting cells are not differentiated into a right and left thickening as in *Paradoxurus*, *Arctictis*, and the Viverrines. The prepuce is hairy, and the glans of the penis is quite short, a little expanded and rounded distally, and without spicules.

General Conclusions with regard to the Perfume-glands.

From the account here given it is clear that the gland in the Paradoxurines varies greatly in position in the genera discussed; but it is interesting to note the gradation in the situation it assumes, especially in the female. In *Arctictis* it is entirely perineal, lying between the anus and the vulva as in *Genetta*, *Viverra*, etc., and in *Hemigalus* and *Cynogale*, although differing structurally from the gland in those genera. In *Paradoxurus* the glandular area passes anteriorly in front of the perineum, so that the vulva lies near its centre. Nevertheless, the labia of the gland, as in *Arctictis*, fold over behind the vulva and clitoris. In *Arctogalidia* the external genital organs are situated quite at its posterior extremity, the secreting area being in front of the clitoris and the labia also folding anteriorly to it. In *Nandinia* the gland is altogether in front of the vulva and disconnected from it. Thus *Nandinia* and *Arctictis* stand at the two extremes.

In the males the differences between *Arctictis* and *Paradoxurus* on the one hand, and *Nandinia* on the other, are equally well marked, but the link in the chain of gradation is wanting, possibly owing to our ignorance of the gland in this sex of *Arctogalidia*.

Another point to consider is which of the two conditions presented respectively by *Arctictis* or *Paradoxurus* and *Nandinia* is the more primitive. I incline to the opinion that the latter is the derivative type; and for this reason — the position of the prepuce considerably in advance of the scrotum is the condition occurring in the Canidæ, Procyonidæ, and Ursidæ, which are the most generalised, on the whole, of existing Carnivores. It also obtains in the Æluroid *Cryptoprocta*. In the Pinnipedia, too, the prepuce is situated a long way in advance of the anus, close to which the scrotum was probably placed before its suppression. On the other hand, the position of the penis just in front of the scrotum is a character in which *Nandinia* resembles the Felidæ, which are regarded as the most specialised of all the Carnivora.

The opinion above expressed can only be tentatively held, however, because the prepuce is close to the scrotum in the Mongooses.

The main features of the glands and external genitalia may be systematically summarised as follows:—

Males *

a. Glands paired, situated behind the prepuce, which lies far in advance of the scrotum at the anterior end of the naked glandular tract; hence the labia of the gland when juxtaposed meet behind the prepuce. Glans penis long or moderately long, and spicular.
  a′. Glans penis subcylindrical, long, richly spicular, and terminated by a styliform process .. .. *Paradoxurus.*
  b′. Glans penis conical, shorter, spicular at base, and without styliform terminal process . ... *Arctictis.*
b. Glands unpaired, situated in front of the prepuce which is close to the scrotum; hence the labia of the gland when juxtaposed meet in front of the prepuce; glans penis quite short and unarmed .... *Nandinia.*

Females.

a. Glands paired, behind and sometimes partially alongside the vulva; labia of the glands when juxtaposed meeting behind the clitoris and vulva.
  a′. Vulva in front of the large naked glandular area .. .. *Arctictis.*
  b′. Vulva near the middle of the naked glandular area, the secretory area extending behind and alongside the vulva . *Paradoxurus.*
b. Glands unpaired, secreting area altogether in front of the vulva; labia of the glandular area, when juxtaposed, meeting in front of the vulva.
  a^2. Vulva situated at the posterior end of the naked glandular tract which is bounded laterally and in front by upstanding labia .. .. *Arctogalidia.*
  b^2. Vulva separated from the naked glandular tract which has a pouch-like depression at its anterior end .... *Nandinia.*

Considered collectively the glands of these genera differ from those of the Viverrinæ in the following particulars:—In the Viverrines the labia of the glands are hairy without and within and form a pair of tumid masses usually closely juxtaposed or as in *Viverra zibetha*, where they are divergent behind, confluent in front behind the prepuce. In no case does the glandular area extend in front of the prepuce or of the vulva, nor does it ever form a flattened naked area covered all over with secretory orifices. In the Paradoxurine genera, on the contrary, the labia, when present as upstanding ridges, are naked within, like the floor of the fossa between them. They are not closely applied and can be so widely divaricated in both sexes that the secreting surface, studded all over with pores, forms a flat or nearly flat area.

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* The glands of this sex in *Arctogalidia* are unknown.

31. Anatomical Notes on the Gruiform Birds *Aramus giganteus* Bonap., and *Rhinochetus kagu*. By P. Chalmers Mitchell, D.Sc., LL.D., F.R.S., F.Z.S., Secretary to the Society.

[Received May 11, 1915: Read May 25, 1915.]

(Text-figures 1–5.)

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In July 1914 the Society purchased from a dealer a bird of unknown source, recognised by Mr. D. Seth-Smith, our Curator of Birds, as being new to our Collection. It turned out to be an example of *Aramus giganteus* Bonap., the Limpkin, Clucking Hen, or Northern Courlan (*Aramus pictus* Bartram of the Brit. Mus. Catalogue, vol. xxiii. p. 238). It is the northern form of the Courlan of S. America, *Aramus scolopaceus*, and is a native of Florida, the Antilles, and Jamaica, somewhat doubtfully accepted as a distinct species because of its larger size, and of the extension of the white stripes, confined in the Courlan to the head and neck, to the back, wing-coverts, and lower parts. The anatomy of *A. scolopaceus* has been studied chiefly by Garrod (P. Z. S. 1876, p. 275) and by myself (P. Z. S. 1901, p. 629). As I could find no record of the anatomical examination of *A. giganteus*, I took the opportunity of dissecting the Society's example when it died after living for a few months in the Gardens; and as I had formerly dissected *A. scolopaceus* along with an example of the Kagu (*Rhinochetus kagu*), I renewed the comparison, by dissecting at the same time another example of the Kagu.

It may be convenient to state at once the general conclusion, that, so far as anatomical characters are concerned, *A. giganteus* resembles *A. scolopaceus* very closely indeed. It would not have surprised me to find such slight differences as I noted between two individuals of the same species. I do not suggest, however, that the two species should be merged. The more experience I gain of avian anatomy, the more I am convinced that systematists are well advised when they rely, at least with regard to the discrimination of species and genera, more on those superficial characters that they can observe in the series of museum collections, than on the uncertain indications afforded by the presence or absence of this or that muscle.

Pterylosis.—An aftershaft is present. There were ten primaries, the most distal being smallest, each covert, as usual, being placed distally to each primary. Dr. Gadow (*Vögel*, in Bronn's Thier-Reich, p. 79) states that there are 11 in *Aramus*, but in some examples of *A. giganteus* and *A. scolopaceus* which I examined with Mr. W. R. Ogilvie-Grant at the British Museum (Natural History) we found only 10. There are also only 10 in *Eurypyga* and *Rhinochetus*. The carpal covert is rather smaller than the carpal remex, and crosses it in the fashion that the secondary coverts cross the secondary quills. A minute plica ties the carpal remex to the most distal secondary quill, and the general disposition bears out the view urged by Degen and myself that the carpal feathers are in series with the secondaries, not with the primaries. The wing is aquintocubital; the diastaxic gap is wide and is occupied by a covert in the normal fashion.

The oil-gland is tufted, and there are twelve rectrices.

The disposition of the feather-tracts, as in *A. scolopaceus*, agrees very closely with Nitzsch's account of *Psophia*.

There were very thick clumps of down on the back, especially on the rump. In the fresh condition these gave off some powder, but detailed examination did not show the presence of true decomposing down. The distribution of powder-downs amongst birds is, as is now well known, far too irregular to be of use in systematic classification.

There are no webs between any of the toes, and the claw of the third digit is unsymmetrical, forming a scoop, slightly notched, but not constituting a definite comb.

Viscera.—Both carotids are present. The trachea is unconvoluted; the rings are highly ossified, and the normal pair of extrinsic muscles and the intrinsic muscles are both present.

The configuration of the alimentary tract is of the generalized type that I have shown (Trans. Linn. Soc., Zool. vol. viii. p. 173, 1901) to underlie the patterns displayed by Charadriiform and Gruiform birds. The duodenum is a long and narrow loop; Meckel's tract is suspended at the circumference of a nearly circular expanse of mesentery; between the duodenum and Meckel's diverticulum there is a single rather wide loop; the diverticulum, which is large and prominent, is placed on the distal limb of the moderately long axial loop, and the distal portion of Meckel's tract is thrown into three or four rather irregular short loops. The cæca are functional, of moderate length, and slightly expanded towards their extremities. The rectum is straight and rather wide. A ganglionated sympathetic nerve chain passes round the mesentery, bending a short way into the more important loops. I have to add to the description I gave of *A. scolopaceus* that there are two bridging veins from the duodenal loop to the distal part of Meckel's tract. The example of *A. scolopaceus* that I examined had been preserved in spirit, and very likely I overlooked the presence of bridging veins. From the evidence afforded by this example of *A. giganteus*, which

I examined before it had been hardened by spirit, I should place the pattern of *Aramus* definitely on the Gruiform stem, rather than at the branching of the Gruiform and Charadriiform stems.

Muscular Anatomy.

Cucullaris.—The cervical portion is much feebler than in *Rhinochetus*, but its posterior edge nearly meets the anterior edge of the rhomboideus externus.

Rhomboideus externus.—A continuous thin sheet of muscle, distally leaving uncovered a good piece of the rhomboideus profundus, and proximally stretching far anterior to it. In *Rhinochetus* the arrangement is similar, but the muscle thins out in the middle region and becomes much thicker in front.

Rhomboideus profundus.—This reaches to the extreme distal end of the scapula and extends forwards almost the whole length of the scapula; it is much thicker than the superficial muscle.

Latissimus dorsi metapatagialis.—This slender muscle is present, lying just under the skin, superficial to the latissimus dorsi posterior and inserted into the skin underlying the humeral feather-tract. It appears to have similar relations in all the Gruiform birds.

Latissimus dorsi anterior and *l. d. posterior.*—These two muscles are well developed, but do not touch at origin or insertion. The tendinous insertion of the posterior division is just deep of, and in contact with, the anchor of the anconæus humeralis; its origin is enormous and is partly from the ilium. In *Rhinochetus* the origin from the ilium is smaller, and although the insertion of the posterior division has similar relations with the anconæus anchor, it is just in contact with the proximal edge of the fleshy insertion of the anterior division. In the Crane the two divisions, especially the posterior, are relatively narrower and do not touch at origin or insertion.

Serrati.—The s. superfic. metapatagialis is large, arising only from the ribs without fibres from the scapula, and is inserted to the skin under the dorsal feather-tract. The s. superfic. anterior is a narrow slip arising from one rib and is inserted by a flat band to the scapula between the two divisions of the sub-coraco-scapularis. The s. superfic. posterior is strong, arising from two ribs with their uncinate processes, and passing to the posterior inferior border of the scapula. The s. profundus is in a series of strong separate slips.

Scapuli-humerales anterior et posterior.—The posterior muscle (*teres major*) is large and is pierced by the expansor secundariorum. I found no trace of the anterior muscle, although Fürbringer states its presence in *A. scolopaceus*, and in the example of that bird which I dissected I noted a few fibres representing it. It is absent in *Rhinochetus*.

Deltoides propatagialis.—A rather narrow muscle, not divided into two peaks. It gives rise to the brevis and longus tendons after a very short common course; the brevis tendon is very broad and gives off a distinct distal slip (gamma of Fürbringer), a median patagial fan, and a separate proximal slip (alpha of Fürbringer). There is no recurrent anchor to the longus tendon. The longus tendon is doubled at the elastic part and receives the whole of the biceps patagialis, the tendon of which is very short. The pectoralis patagialis is large and runs to the patagial tendon, where it divides into longus and brevis slips. The condition in *Rhinochetus* is as I have already figured (*loc. cit.* text-fig. 76), except that the alpha and gamma divisions of the brevis were rather better separated.

Deltoides major et minor.—The major is a strong muscle reaching down to the end of the third quarter of the humerus; it is shorter in *Rhinochetus*. The minor, as in other Gruiform birds, is quite separate, and is inserted to the other side of the insertion of the pectoralis minor.

Pectoralis thoracicus.—A very strong muscle with a feeble fibrous anchor to the humerus, and a single elongated tendinous insertion. In *Rhinochetus* the muscle is similar, except that it is narrower, in association with the shallow keel of the sternum.

Supra-coracoideus (*pectoralis minor*), *coraco-brachialis externus*, *coraco-brachialis internus*, and *sub-coraco-scapularis.*—Practically identical in their relations in the two species of *Aramus* and in *Rhinochetus*, except that in *Rhinochetus* the coracoidal origin of the last-named muscle is relatively very much larger.

Anconæus.—The humeralis division, as in the vast majority of birds, is a strong muscle arising from the greater part of the humerus, and is cleft proximally. The scapular head, in addition to the stout anchor to the humerus described in connection with the latissimus dorsi muscles, has the origin from the scapula forked in *Aramus*, simple in *Rhinochetus*. The anconæus caput coracoideum (expansor secundariorum) in *Aramus* presents the arrangement described as "ciconine" by Garrod; that is to say, it arises in the axilla from a triangular ligament which passes into a stout tendon running to be inserted to the proximal secondary quills. I have already stated (P. Z. S. 1901, p. 645) that this arrangement is usual in Gruiform birds, but that I found the muscle feeble, although present, in *Rhinochetus* and *Eurypyga*. In the example of *Rhinochetus* which I used in the dissections I am now describing, I found no trace of the expansor secundariorum in either of the wings. This may serve as another of the many warnings against attaching systematic value to the absence of an anatomical structure, as it may have been lost independently by different descendants of a common ancestor.

Biceps brachii.—In *Aramus* the acrocoracoidal portion of the muscle gives rise to a tendon which, although closely associated with the humeral portion, can be traced separately to the ulna, the humeral portion going to the radius. In *Rhinochetus* the division of the tendon of insertion to the radius and ulna is forked at the extreme distal end. The peculiar accessory head of the biceps, first noted by Beddard (P. Z. S. 1891, p. 14) and confirmed by myself (P. Z. S. 1901, p. 639) from dissection of another example of *Rhinochetus*, was doubtfully represented in the present example, an old and excessively fat bird, by a lump of fat and fibrous tissue.

Ilio-tibialis internus (*sartorius*).—As in other Gruiform birds, rather easily separable from the glutæus maximus.

Ilio-tibialis (*glutæus maximus*).—This large muscle, with rather weak median and very strong post-acetabular portions, had the disposition found in Gruiform birds generally.

Ilio-trochanterici posterior, *anterior*, and *medius*, were all distinct and well developed as in other Gruiform birds, but the small median muscle (*glutæus quartus*) was absent in *A. giganteus* as in *A. scolopaceus*; in the present example of *Rhinochetus* it was just separable.

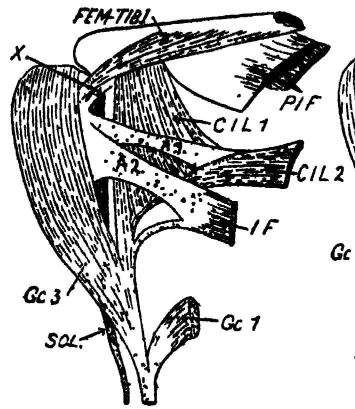
Caud-ilio-femoralis (*femoro-caudal* and *accessory*).—The femoro-caudal was absent in *A. giganteus* as in *A. scolopaceus*, present but small in *Rhinochetus*; the accessory was large, but with an area of tendinous degeneration in *A. giganteus*, precisely as in *A. scolopaceus*, absent in *Rhinochetus*.

Ambiens.—Present in both *A. giganteus* and *Rhinochetus*, its slender tendon, after passing round the knee, receiving a strong anchor from the head of the fibula.

Caud-ilio-flexorius (*semitendinosus* and *accessory semitendinosus*). *Ischio-flexorius* (*semimembranosus*). *Gastrocnemius*, *middle*, or *posterior femoral head*.—For convenience, to explain the interesting relations of this group of muscles, I have repeated here, as text-figures 1–4, the text-figures 81–84 in my paper on Gruiform birds already published in the Proceedings of this Society (P. Z. S. 1901, pp. 650–651). In *A. giganteus*, as in *A. scolopaceus* (text-fig. 2), the semitendinosus (C.I.L. 2) is wide, but not so large as the semimembranosus (I.F.), except towards its insertion, whereas in *Rhinochetus* it is enormous, much larger than the semimembranosus. In *A. giganteus* the accessory semitend. (C.I.L. 2) is a broad triangular muscle, meeting the semitend. in an oblique raphe, exactly as in *A. scolopaceus* (text-fig. 2), and then running down to join the middle head of the gastrocnemius, which it covers; the semimembr., also as represented in that figure, sends a slip to the conjoined semitendinosus and accessory semitend., and passes on to the tibia by a flat ligament (A. 2). There was also a thin flat ligament from the semitend. raphe to the tibia, which I did not find in *A. scolopaceus*, but which I found in *Rallus* (text-fig. 1, A. 1).

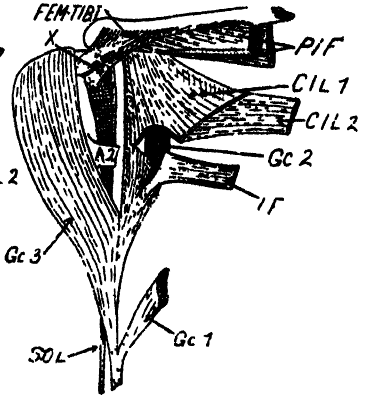
The condition of this group of muscles in the example of *Rhinochetus* that I am now describing, corresponded, except in one important respect, with what I found on a former occasion and described as resembling the condition in *Otis* (text-fig. 3). The semitendinosus, accessory semitend., and semimembranosus unite to form a flat tendon of insertion to the tibia (A. 2) plainly

Text-figure 1.



Knee-muscles of *Rallus longirostris*

Text-figure 2.



Knee-muscles of *Aramus scolopaceus*

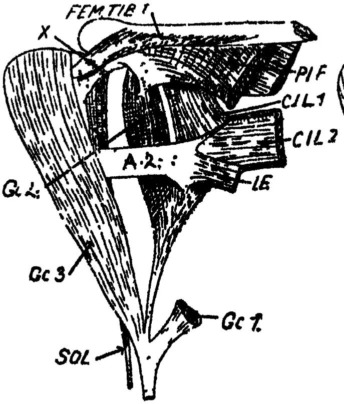
Musculature of knee; right leg, internal view

FEM-TIB-1 Internal separate slip of femoro-tibialis (vastus internus)
X. Ligament from femur to tibia
P I F Pub-ischio-femorales (adductors).
C I L Caud-ilio-flexorius. *C I L 1* Femoral insertion of caud-ilio-flexorius (accessory semitendinosus) *C I L 2* Semitendinosus
I F Ischio-flexorius (semimembranosus).
A 1 Anchor to tibia of *C I L.*
A 2 Anchor to tibia of *I.F.*
Gc 1 External femoral division of gastrocnemius.
Gc 2. Internal femoral divison of gastrocnemius
Gc 3 Tibial division of gastrocnemius
SOL Soleus.

In text-figure 2 the caud-ilio-flexorius has had a piece removed to exhibit the deeper lying *Gc 2.*

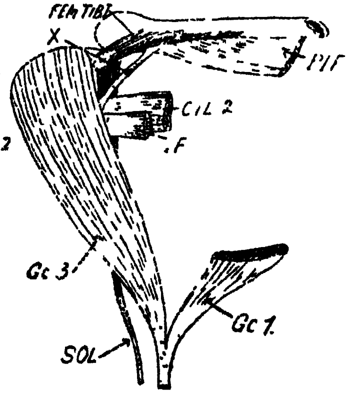
The tendinous areas are dotted.

Text-figure 3.



Knee-muscles of *Otis tarda.*

Text-figure 4.



Knee-muscles of *Heliornis fulica*

Description and lettering as in text-figures 1 & 2 identical with the tendon of insertion of the semimembranosus in *Aramus* and *Rallus*. This tendon arises from the semitendinosus raphe, and the muscular bellies pass under it, meet a separate muscle (text-fig. 3, Gc. 2) arising from the femur just proximal to the accessory semitendin., and form a strong tendon that joins the common tendon of the gastrocnemius. A glance at text-figures 1, 2, and 3 will show that this muscle, marked Gc. 2, appears to be present in *Rallus*, *Aramus*, *Otis*, and *Rhinochetus*, but that in the two former it is fused along its edge with the accessory semitendinosus, whilst in the two latter it is free. If, then, we identify the muscle marked Gc. 2 in text-fig. 3 with the middle head of the gastrocnemius, it seems a sufficient statement of the facts to say that the middle head of the gastrocnemius in *Rallus* is either absent, or fused with the accessory semitendinosus. But in both species of *Aramus*, although the accessory semitendinosus is sufficiently broad to pass both for itself and a fused ralline-like middle head of the gastrocnemius, there is, in addition, a distinct middle head (text-fig. 2, Gc. 2) apparently absent in *Rallus*. In *Psophia*, the middle head of the gastrocnemius is double, one portion corresponding with the Gc. 2 in text-fig. 2, another with the Gc. 2 in text-fig. 3. In my paper already cited (P. Z. S. 1901) I stated that the external head of the gastrocnemius in *Otis* was trifid, one of the three origins passing under the biceps. I do not doubt but that the latter is morphologically identical with the slip marked Gc. 2 in text-fig. 2. In the example of *Rhinochetus* that I am now describing, I found precisely the same condition; not only is the Gc. 2, represented in text-fig. 3, present, but there is also a separate middle head corresponding with the Gc. 2 of text-fig. 2. Dr. Beddard (P. Z. S. 1891, p. 16) has published a description and an incompletely lettered figure of the gastrocnemius and its relations in *Rhinochetus*. Although his description is difficult to follow, as it omits reference to the tibial head of the gastrocnemius which, so far as I know, occurs in all birds, and refers to a head "formed by a broad flat tendon to the head of the fibula," a disposition which is at least abnormal in Avian anatomy, I infer that the arrangement of the gastrocnemius in the example of *Rhinochetus* that he dissected was identical with that which I describe here.

For some time I have been collecting notes on the various fashions in which the middle head of the gastrocnemius and the accessory semitendinosus are disposed in birds, but I do not wish to offer these results for publication until I can present a fairly complete picture of their distribution in the Avian system. Dr. Gadow (*Vögel*, in Bronn's Thier-Reich, p. 184) distinguishes three conditions of this complex: (i.) when the accessory semitendinosus cannot be separated from the middle head of the gastrocnemius; (ii.) when both muscles are present but quite distinct except in so far as they may be connected by secondary tendons; (iii.) when the accessory semitendinosus is absent but the middle head of the gastrocnemius present. This grouping will not contain all the facts; there is a condition, as in *Rhinochetus* and *Psophia*, which corresponds with Gadow's second group, except that there is, in addition, a second distinct middle gastrocnemius.

Gastrocnemius, external femoral head, and *internal tibial head. Ilio-fibularis* (*biceps*, with sling and anchor). *Soleus.*—All these presented no peculiarity, and were similar in the two species of *Aramus* and in *Rhinochetus.*

Pub-ischio-femorales (*adductors*).—In all three birds both were present, without trace of tendinous degeneration, and, as in most Gruiform birds, the internal muscle was much stronger and wider than the external muscle.

Ischio-femoralis (*obdurator externus*), *obdurator* (*obdurator internus*); *accessorii obdurator is.*—With regard to these muscles, I have to note only that the obdurator externus was notably small in *A. giganteus*, and that the area of insertion, to the shape of which Garrod attached importance, was markedly triangular in that bird, as in *A. scolopaceus* and in Rails and Cranes. It is much more oval in *Rhinochetus.*

Peroneus superficialis and *peroneus profundus.*—In both species of *Aramus* and in *Rhinochetus* the superficial muscle is the more important, with a broad superficial origin, extensive origin from the fascia of the adjacent muscles and, in *Aramus*, almost no deep origin, but a certain amount of it in *Rhinochetus.* The anchor to the sustentaculum of the flexor tendons is broad in all three and shows traces of being broken into separate slips. The tendinous slip to the flexor of the third digit is well developed in all three birds. The deep muscle is very strong in *Rhinochetus*, arising from a large part of the fibula, beginning at the insertion of the biceps tendon, and from the adjacent surface of the tibia. It passes in the normal fashion into a flattened tendon running in a groove under the slip to digit III of the superficial muscle. In *A. scolopaceus* I did not find it, but in *A. giganteus* it was represented by a very minute muscular head arising high up from the fibula opposite the biceps insertion, and passing at once into a most slender ossified tendon, so closely adherent to the fibula that, unless it were specially searched for, it might easily be missed. It has the usual insertion by a very thin flattened tendon in a groove under the slip to III. The tendons of both peroneals were ossified in *Aramus*, as in many other Gruiform and Limicoline birds, but in *Rhinochetus* there was no trace of ossification. I have shown, in a former communication to the Society ("The Peroneal Muscles in Birds," P. Z. S. 1913), that in Gruiform birds there is a tendency for the deep peroneal to become reduced or to disappear, so that it would not be remarkable to find it present in *A. giganteus* and absent in *A. scolopaceus*, even if these forms were not specifically distinct.

Tibialis anticus; *Extensor digitorum communis*; *Flexores perforantes et perforati* of digits II and III.—These muscles are all present in both species of *Aramus* and in *Rhinochetus* and have the disposition that is normal in birds generally. The most notable point of difference is that in *Aramus* the tendons are all ossified, above and below the ankle, and are unossified in *Rhinochetus.* The flexor tendon of digit III is connected with the perforated flexor tendon of the same digit by a strong slip.

Flexores perforati, of digits II, III, IV. In all three birds, as in Gruiform birds generally, there are three heads for this group of muscles, and fibres from each of the three tendons can be traced to each of the three heads. The ambiens head is the tendon of the ambiens muscle, which passes under the biceps ligament, that is to say, between it and the fibula. The fibular or external head arises by a tendon from the fibula, proximal to the insertion of the biceps and passing superficially to the biceps tendon. The deep or femoral head is fleshy from between the condyles of the femur.

Flexor longis hallucis.—In all three birds this arises by a single head from between the condyles of the femur.

Flexor profundus.—Arises from the shaft of the tibia close under the fibula. In *Aramus* the tendons of the deep flexors are nearly equal in size; in *Rhinochetus* the tendon of the longus hallucis is relatively smaller. In *A. giganteus* the relations between the two deep tendons are much as I represented in *A. scolopaceus* (P. Z. S. 1901, p. 654), except that the vinculum to the other deep flexor is spread over the branches to the digits rather more, as in the figure of *Eurypyga* given on the same page. The present example of *Rhinochetus* was exactly similar in this respect to the figure I have given, also on the same page.

The muscular anatomy affords small ground for separating *A. giganteus* from *A. scolopaceus.* The most notable differences relate to muscles that are degenerate in the group, and that might even vary individually—such as the presence of a teres minor in *A. scolopaceus* which is absent in *A. giganteus*, and the presence of a peroneus profundus in the latter species and its absence in the former.

The muscular arrangements in which the two species of *Aramus* agree and differ from Cranes are more numerous, and are in conformity with the separation of a sub-family Araminæ.

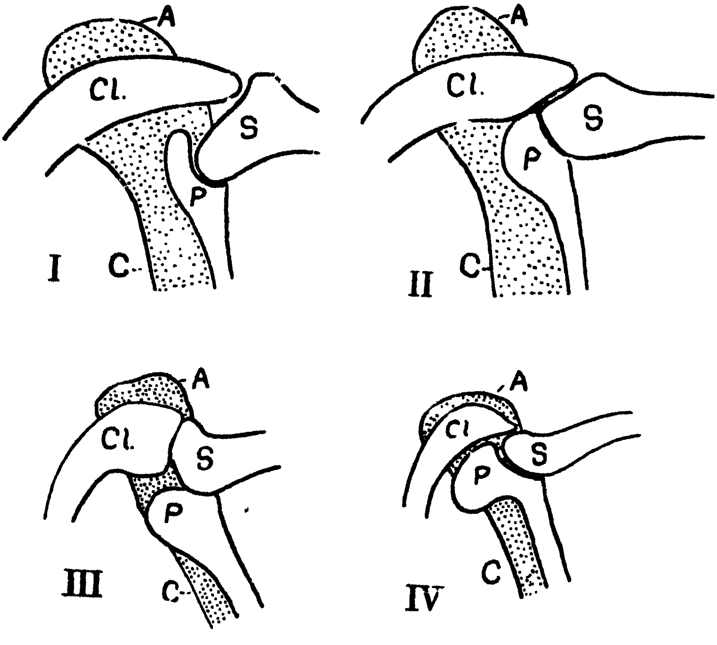
Osteology.

I have noted only a few osteological points, the systematic value of which I do not propose to discuss.

Like that of *A. scolopaceus,* the skull of *A. giganteus* is strongly schizorhinal; the lacrimals are not fused with the skull as occurs in *Rhinochetus* and Limicoline birds. The palate is widely schizognathous with a long pointed vomer, and the pterygoids are short, and expanded anteriorly as in *Grus.* Also, as in *Grus,* there is a pair of occipital foramina, and strong descending exoccipital processes, both absent in *Rhinochetus.* The skulls of both species of *Aramus* are exceedingly like those of true Cranes, the likeness extending not only to the larger characters that have been employed in classification, but to the minute configuration of the bones.

Sternum.—In Gadow's valuable synoptic table (*Vögel*, in Bronn's Thier-Reich, p. 79), he states that the external spine is very large in Grues (in which he includes *Aramus*) and very small in *Rhinochetus*, and that the internal spine is absent in Grues and in *Rhinochetus*. With regard to the internal spine, I confirm his statement for Cranes, *Rhinochetus*, and both species of *Aramus*. The external spine is certainly small in *Rhinochetus*, but it was also

Text-figure 5.



Shoulder-girdle articulations in Gruiform Birds. I. *Balearica.* II. *Grus* (*australasiana & carunculata*) III. *Aramus giganteus.* IV. *Rhinochetus kagu.*

A. Acrocoracoidal process of coracoid. *C.* Coracoid. *Cl.* Clavicle. *P.* Procoracoidal process of coracoid. *S.* Scapula.

small in both species of *Aramus*. In the examples of *Grus* that I have examined (*G. australasiana* and *G. carunculata*) the external spine was very large and hollowed for a coil of the windpipe. In an example of *Balearica*, on the other hand, it was as minute as in *Aramus* and *Rhinochetus*. The sex of the skeleton had not been noted, but it appears probable that the huge external spine of Cranes is developed in connection with the windpipe, and is not to be regarded as a character of systematic value.

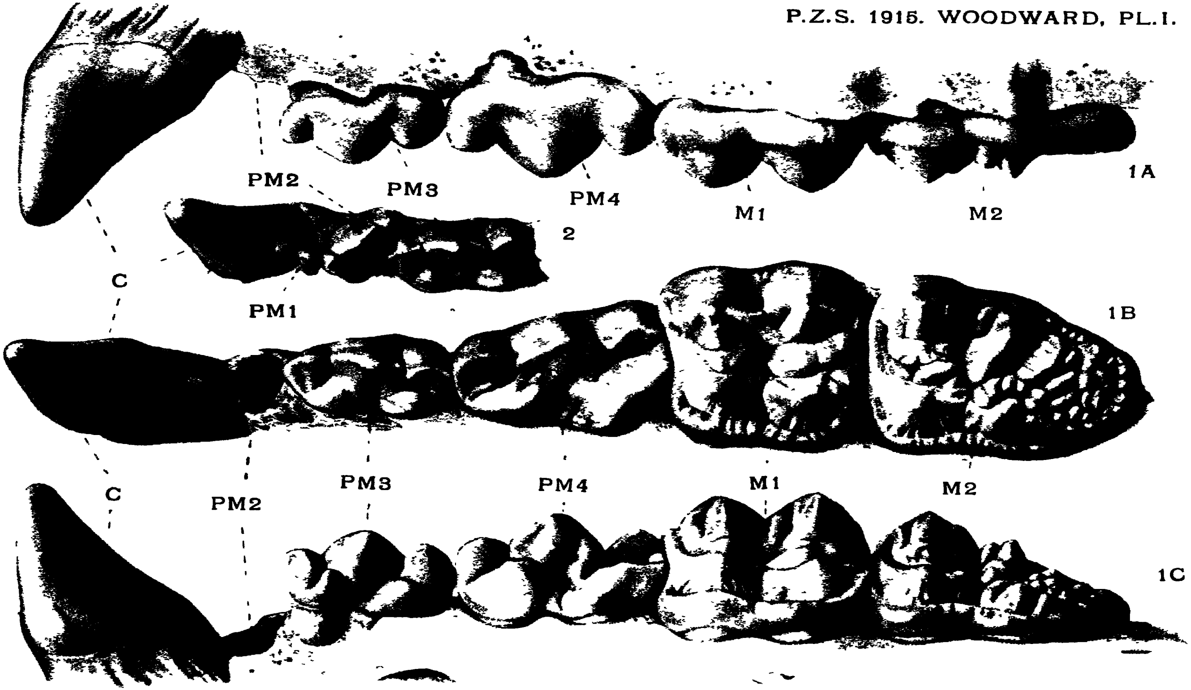
Shoulder-girdle articulation.—In text-fig. 5 I give drawings of the relations of the coracoid, scapula, and clavicle, to which Fürbringer has paid so much attention in his great monograph on Birds. Fürbringer has figured the same structures in the case of *Grus*, *Psophia*, *Aramus*, *Eurypyga*, *Dicholophus*, and *Otis* (Morph. u. System. der Vögel, 1888, pl. ii., figs. 40–45). Comparison of his figures with those that I give here, will show that, within the limits of Gruiform birds, the characters vary considerably and are difficult to value for systematic purposes. *Balearica* agrees very closely with the figure Fürbringer gives for *Grus*, except that the procoracoidal process is not quite so large. My figure of *Grus*, which applies equally to *G. australasiana* and to *G. carunculata*, shows much closer articulation of the clavicle and scapula than was figured by Fürbringer, as well as a smaller procoracoidal process.

Aramus giganteus differs from the figure given by Fürbringer, possibly for *A. scolopaceus*, in that the articular end of the clavicle forms a broad flattened plate articulating with the scapula.

Rhinochetus has a large procoracoid, and very slight articulation of clavicle and scapula. According to Furbringer, *Psophia* shows the most complete articulation of scapula, clavicle, and procoracoid.

Systematic Position of *Aramus*. I have already shown (P. Z. S. 1901, pp. 629–655) that *A. scolopaceus* fitted naturally with Gruiform birds, and the examination of *A. giganteus* confirms this in every respect.

P.Z.S. 1915. WOODWARD, PL. I.



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1. AELUREIDOPUS BACONI. 2. AELUROPUS MELANOLEUCUS.

32. On the Skull of an extinct Mammal related to *Æluropus* from a Cave in the Ruby Mines at Mogok, Burma.

By A. SMITH WOODWARD, LL.D., F.R.S., V.P.Z.S.

[Received May 25, 1915: Read June 8, 1915.]

(Plate I.* & Text-figure 1.)

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Æluræidopus baconi, gen. et sp. n.	428

The rare and remarkable mammal *Æluropus*, now confined to the highlands of eastern Thibet, is evidently the survivor of a group which must have had a wide geographical range in comparatively modern geological times. It is so completely intermediate between the Procyonidæ and the Ursidæ, that it is sometimes placed in the one family †, sometimes in the other ‡; and its relationships to the Pliocene *Hyænarctos* are so obvious §, that it must doubtless be regarded as a somewhat modified survivor of the common stock from which the Procyonidæ and Ursidæ have diverged. No closely related fossil forms, however, have hitherto been recorded; and the recent discovery of a skull of an allied extinct species is therefore of interest.

The new specimen (text-fig. 1) was obtained from a cave at the ruby mines, Mogok, Upper Burma, by Mr. A. L. Bacon, and brought as a gift to the British Museum by Mr. F. Atlay. The skull lacks both zygomatic arches and the anterior end of the palate with the incisors and three of the premolar teeth. It must, in fact, have lain exposed for some time in the cave; for the whole of the sagittal crest has been gnawed away by a rodent, evidently a porcupine ‖, and there are similar tooth marks along the lambdoidal border and other parts of the occiput. Otherwise the fossil is well preserved and all its characteristic features are shown.

Although it is not mineralised, the bone is remarkably dense and heavy, as in the skull of *Æluropus melanoleucus* ¶. Nearly all the sutures between the elements are closed, and the specimen represents a fully adult individual, which was slightly larger and more robust than the described examples of the existing species. It agrees with the latter in all essential respects, such as the

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* For explanation of the Plate see p. 428.

† E. Ray Lankester, "On the Affinities of *Æluropus melanoleucus*," Trans. Linn. Soc., Zool., ser. 2, vol. viii. (1901), pp. 163–172, pls. xviii.–xx.

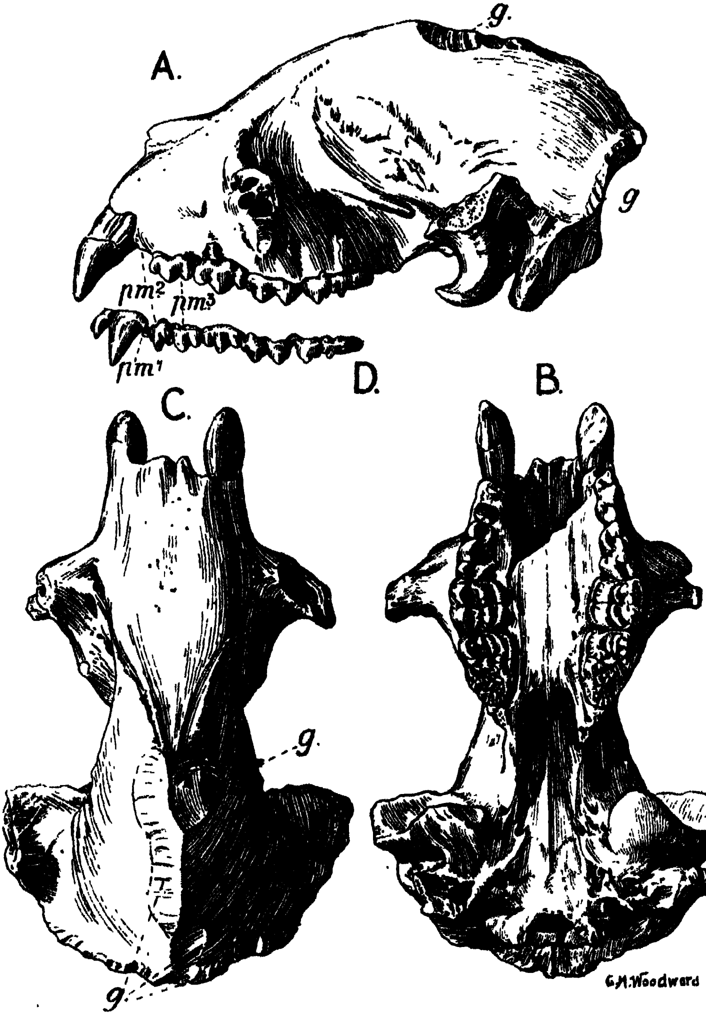
‡ K. S. Bardenfleth, "On the Systematic Position of *Æluropus melanoleucus*," Mindeskrift for Japetus Steenstrup (1913), art. xvii.

§ H. Winge, E Museo Lundii, vol. ii. (1896), pt. ii. no. 2, p. 62.

‖ Similar gnawing of fossil bones has been noticed by R. Lydekker, "The Fauna of the Karnul Caves," Palæont. Indica, ser. 10, vol. iv. (1886), p. 25.

¶ E. Ray Lankester, *loc. cit.* p. 165.

Text-figure 1.



A.–C.—*Ælureidopus baconi*, gen. et sp. nov.; imperfect skull from the left lateral (A.), palatal (B.), and upper (C.) aspects; one-quarter nat. size.

g. Marks of gnawing by rodents, probably porcupines.

D.—*Æluropus melanoleucus* A. Milne-Edw.; left upper dentition, outer aspect; one-quarter nat. size.

pm. 1–3. First, second, and third premolars.

disposition of the basicranial foramina, the ending of the palate posteriorly between the last molars, the position of the infra-orbital foramen on the cheek, and the absence of a postorbital prominence. It differs only in its steeper frontal profile and certain minor characters. The inner face of the stout mastoid process, for example, is irregularly ridged, not smooth as in *Æluropus*. The foramen which pierces the inner wall of the lachrymal pit in the existing species, is behind this pit in the fossil.

The molar and premolar teeth, so far as preserved, agree closely with those of *Æluropus*, and exhibit only a less marked crimping and less tendency to subdivision of some of the cusps. Except these features, there is nothing to remark about the molars (Pl. I. figs. 1 A–C, *m.* 1, *m.* 2). The upper sectorial (*pm.* 4) is noteworthy for the simple and robust character of its antero-internal cusp or protocone. The third premolar (*pm.* 3) is preserved only on the left side and agrees precisely with that of *Æluropus*, but is relatively a little larger. Even in the existing genus the space for the first two premolars is so short that the double-rooted pm. 2 is thrust crosswise and pm. 1 is reduced to a single minute cusp (Pl. I. fig. 2); but in the imperfect fossil, which does not retain either of these teeth, the corresponding space is still shorter. The bone is broken away on the right; but it seems to be sufficiently well preserved on the left to show that only one single-rooted premolar originally occupied this position. At least, a single socket of moderate size fills the whole of the space between pm. 3 and the canine. The canine (*c.*), broken on the left, but completely preserved on the right side, closely resembles that of *Æluropus*, even to the faint crimping of its posterior keel; it is, however, slightly more robust than in the described specimens of the existing species.

Some of the principal measurements of the fossil, in fractions of a metre, are as follows:—

			M.
Length from anterior border of nasals to posterior face of occipital condyles.			0·25
Maximum width between outer borders of mastoid processes, about			0·18
Maximum width of basioccipital between tympanic bullæ.			0·043
Frontal width at postorbital point			0·066
Depth of snout from alveolar border above pm. 3, about			0·075
Depth between alveolar border and beginning of sagittal crest, about			0·135
M. 2—	maximum	length	0·038
	„	width	0·029
M. 1—	„	length	0·027
	„	width	0·031
Pm. 4—	„	length	0·029
	„	width	0·021
Pm. 3—	„	length	0·023
	„	width	0·014
Canine—	„	length of base	0·023
	„	width of base	0·016

The fossil from Mogok, therefore, differs essentially from the skull of the existing species of *Æluropus* in the shortness and bluntness of the snout, with the consequent reduction of space for the anterior premolars. It remains only to decide whether these differences are to be regarded as of generic or of specific value. If the anterior premolars were merely reduced in size, there need be no hesitation in adopting the latter alternative; but as pm. 2 differs fundamentally in having only a single root while pm. 1 was probably absent, I am inclined to refer the fossil to a distinct genus. I propose that this genus be named *Ælureidopus*, and defined from *Æluropus* by the presence of only three upper premolars of which the foremost has a simple root. The species represented by the skull now described may be appropriately named *baconi* after its discoverer.

EXPLANATION OF PLATE I.

Fig. 1. *Ælureidopus baconi*, gen. et sp. nov.; left upper dentition from the outer (A), lower (B), and inner (C) aspects, partly restored from the right side of the fossil, nat. size; *c*. canine; *pm*. 2, single socket for second premolar; *pm*. 3, 4, second and third premolars; *m*. 1, 2, first and second molars.

Fig. 2. *Æluropus melanoleucus* A. Milne-Edw.; left upper canine (*c*.) and first to third premolars (*pm*. 1–3), lower aspect, nat. size.

33. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

[Received and Read May 25, 1915.]

(Text-figures 1–6.)

XVII. ON *TÆNIA TAURICOLLIS* OF CHAPMAN AND ON THE GENUS *CHAPMANIA*.

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I obtained, on June 30th, 1914, a large number of examples of Cestodes from an American Rhea (*Rhea americana*) which died in the Society's Gardens on the previous day. All these worms were found in the right cæcum, and none of them in the small intestine. As is known, the cæcum is very rarely found to be inhabited by Cestode parasites, though there are cases on record *.

From this bird three species of Cestodes have been described. Of these three, *Cittotænia rheæ* may be set aside at once as having nothing in common with the species which forms the subject of the present remarks. This latter species is identical with either *Tænia tauricollis* of Chapman or *Tænia struthionis* Houttuyn among those which have been found in *Rhea*, or is another species altogether. *Tænia tauricollis* has been placed in a genus *Chapmania* (which is not widely different from *Idiogenes*), while *Tænia struthionis* is now assigned to *Davainea*. In spite of this generic separation, which depends upon the not at all full description of *Davainea struthionis* by Parona † and von Linstow ‡, I am by no means certain that they are not actually identical at least generically.

Davainea struthionis, though found in the Ostrich, is stated by Fuhrmann § to occur also in *Rhea americana*; but the statement of Fuhrmann is not advanced with absolute positiveness; and it is only a statement in that no characters of *Davainea struthionis* are given by him to confirm the identification. The fullest account of the structure of *Davainea struthionis* is that of v. Linstow. Parona's notes give no anatomical detail to speak of. It is probably therefore to the former paper that the responsibility for including this species in the genus *Davainea* by all subsequent authors is to be referred. Von Linstow himself assigns the worm to the genus *Davainea* by reason of the form of the hooks. That character, however, is now known in other genera—though all of them of the family Davaineidæ.

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* See Bronn's 'Thier-Reich,' Bd. iv. Abth. 1 B, p. 1625.

† Ann. Mus. Civ. Genova (2 a) ii. 1885, p. 425.

‡ Arch. f. mikr. Anat. xlii. 1893, p. 447.

§ "Die Cestoden der Vögel," Zool. Jahrb. Suppl.-Bd. x. 1908, pp. 6 and 19.

Those who have written subsequently upon this species, *Davainea struthionis*, have probably accepted its generic rank rather from the remarks of Max Braun than from the facts detailed in v. Linstow's memoir. The former has pointed out in Bronn's 'Thier-Reich'* that the alleged ovary of v. Linstow, consisting of a number of separate spherical masses, is not indeed the ovary, but an instance—largely met with in the genus *Davainea*—of the "Parenchymkapseln" of German writers, in which the ripe ova are massed after the disappearance of the uterus (when that sac is clearly developed in the genus, which would seem to be not always). Apart from this interpretation of the "ovary" of v. Linstow and the nature and distribution of the setæ according to v. Linstow, there is nothing in the description of that writer which would justify the reference of "*Tænia struthionis*" to the genus *Davainea*. It will be observed that there is therefore no reason to distinguish this worm from *Chapmania tauricollis*, at any rate so far. The detached masses of ripe ova correspond with what I shall shortly describe in that species, where the uterus is more or less broken up into partly separate cavities containing eggs. The general form and size of the species which has been termed *Davainea struthionis*, as figured by Parona†, is precisely what I have found to characterise the worm from *Rhea americana*, which in other ways agrees positively with the descriptions extant of *Chapmania tauricollis*. We have, however, to assume, if this identification be correct, that v. Linstow has missed the paruterine organ. This is, however, not evident in immature proglottids. I can hardly claim to have proved specific identity; but I believe it would be difficult on the facts known to deny generic identity between these two species.

In the meantime, however, I identify the species described in the present paper with that described by Chapman, Fuhrmann, and others as *Tænia*, *Davainea*, or *Chapmania tauricollis*. It reaches a length of fourteen inches or so and has thus much the dimensions given by Chapman ‡. It is held that *Tænia argentina* of Zschokke § is the same species. If so, there would appear to be a discrepancy in that the measurement of length given by Zschokke is 8–9 cm. I am able, however, to clear up this difficulty. The majority of my specimens agreed with Chapman's in their dimensions; but in a few the length was not greater than 8 cm. or so.

The anterior segments of the body form a long tract, which is very slender and widens out more or less suddenly to the wider

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* Bd. vi. pt. ii. p. 1446.

† Ann. Mus. Civ. Genova (2*a*), ii. 1885.

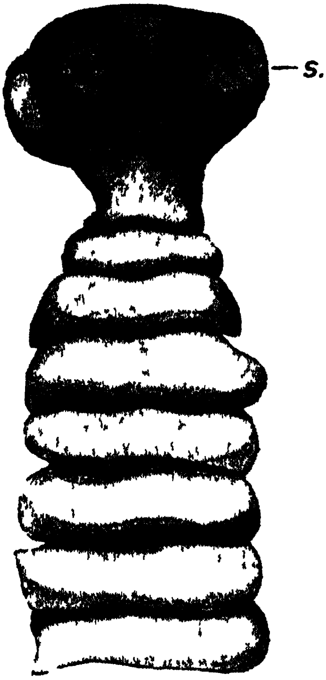
‡ Proc. Acad. Sci. Philadelphia, 1876, p. 14.

§ Centralbl. f. Bakt. u. Paras. iii. 1888, p. 2.

(3-4 mm.) posterior region. The most posterior segments are hardly, if at all, longer than wide. There is no neck.

The figure given by Chapman * of the scolex and anterior segments is quite in accord with the view that the species described by himself is that which I regard here as "*Tænia tauricollis.*" He does not, however, figure or make any reference to hooks upon the rostellum (or, for the matter of that, elsewhere). Monticelli †, however, in his fuller description, found the hooks, which he described as "minutissimi uncini." It would not be difficult to miss these hooks; I find from a note made by myself upon the living worm that no hooks were seen. I have, however, closely examined the scolices of two preserved examples—the only scolices which I possess—and find traces of the hooks in one individual only. The other specimen was

Text-figure 1.



Scolex and anterior segments of *Chapmania tauricollis*.

s. Sucker.

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* Proc. Acad. Sci. Philadelphia, 1876, p. 14.
† Nat. Sicil. xii. 1892-3, p. 208.

devoid of hooks. The one which showed them only possessed a few, which needed a high-power lens and good illumination to show them up. It seems to me that they may easily be shed. I am quite unable to make any statement as to the shape of these hooks. They appeared to be little more than acicular in form, like the hooks of the suckers in some *Davainea*. The feebleness of the rostellar hooks seems to me to be related to the little marked character of the rostellum in this and other forms. I may remark that there is no reason to believe that the present species has any hooks upon the suckers [*]. I shall return later to the questions of systematic arrangement which depend upon the presence of hooks in connection with the genera *Zschokkeella* and *Inermicapsifer* and some others.

In spite of the fact that Chapman described the genital pores of his species as alternating irregularly, the genus *Chapmania* has been defined by some subsequent writers as unilateral, at any rate in the particular species *Chapmania tauricollis* [†]. Chapman himself remarked that five pores might follow consecutively upon the same side of the body. I have seen ten segments in series with the genital pores all upon the same side. It is therefore obvious where the error may have crept in. The genital pores lie at about the middle of the lateral border.

I shall now deal with a few points in the internal structure of this Cestode.

The *cirrus-sac* does not seem to me to have been fully described by Fuhrmann. The *cloaca genitalis*, as he has pointed out, is deep and expands within the cortex in a funnel-shaped way. Into the middle of this funnel opens the cirrus-sac, and through it projects often the protruded cirrus. The cirrus-sac appears to consist of two distinct regions, or it may be, as I shall point out later, that the cloaca genitalis consists of two distinct regions. In any case a bottle-shaped sac opens into what is unquestionably the cloaca genitalis, the neck of which "bottle" is much shorter than the rest. This relatively narrow tube has muscular walls quite continuous with those of the rest of the cirrus-sac, and in it lies the cirrus, which nearly fills up its lumen in cirrus-sacs, which are in an average state of protrusion of the cirrus. The rest of the cirrus-sac extends into the body of the worm some way inwards of the lateral water-vascular tube and ends in a retractor muscle, as has been described by Fuhrmann. The flask part of the cirrus-sac is divided from its narrow neck by a sphincter-muscle, which forms a collar within the lumen of the sac, and to the inside of this a fan-shaped bunch of muscular fibres, provided with nuclei at their internal ends, further blocks the lumen and serves, as I imagine, as a retractor of the cirrus. The vagina opens at the junction of the neck and the flask-shaped region, a fact which rather tends to prove that the neck region really belongs to the cloaca genitalis, unless it be remembered that the male and female genitalia have really a common origin and are parts of a single sytem. The various facts to which attention has been called are illustrated in the accompanying figure of the cirrus-sac and its external orifice (text-fig. 2).

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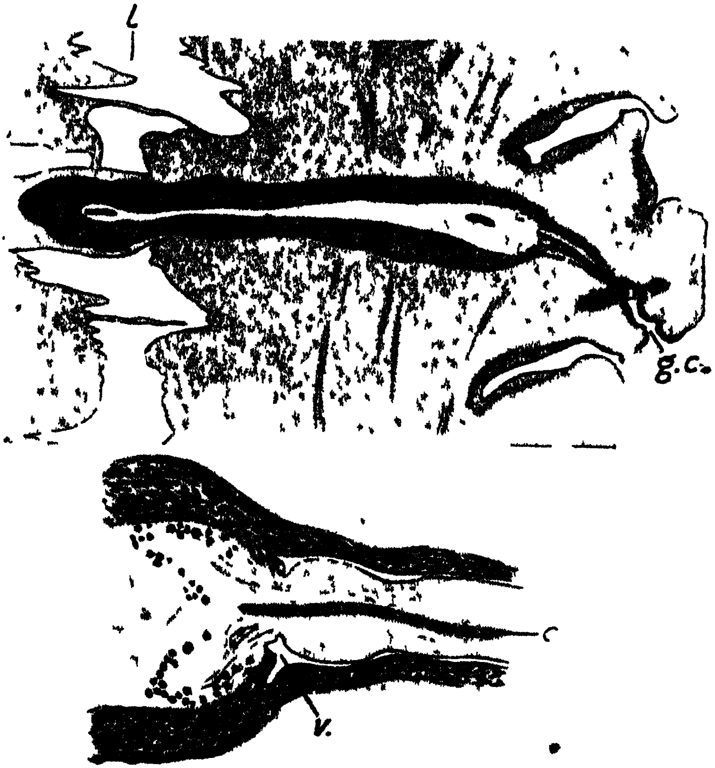
[*] Fuhrmann, however (Rev. Suisse Zool. iv. 1896, p. 111), not only refers to hooks upon the rostellum, but speaks of having seen the evidence of hooks upon one sucker. The definitions of the genus *Chapmania* given by Fuhrmann and Ransom do not use hooks upon the suckers as a character of that genus.

[†] *I. e.*, Ransom, Proc. U.S. Nat. Mus. vol. xl. 1911, p. 637. Also used as a character of "*Tænia argentina*" (believed to be synonymous by Zschokke, Centralb. Bakt. u. Paras. iii. 1888, p. 1).

Text-figure 2.



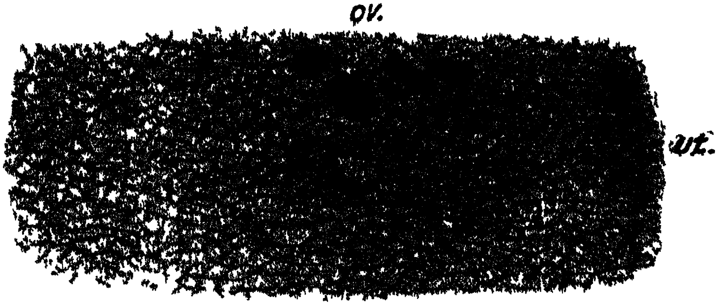
Horizontal section through cirrus-sac.

In the lower figure the junction of the two parts of the cirrus-sac is shown more highly magnified.

g.c. Genital cloaca. *c.* Cirrus. *v.* Muscular valve-fold separating the narrow part of the cirrus-sac from the wider region. *l.* Water-vascular tube.

The earliest appearance of the *uterus* is represented in text-fig. 3. It is there seen to consist of a modified tract of medullary tissue lying anteriorly to the male and female gonads, at about the middle of the proglottid and on a level with the cirrus-sac. It forms a nearly straight line about the middle of the proglottid, wider in the middle of its length and tapering off to the side of the proglottid remote from the cirrus-sac, in which direction it does not reach the lateral water-vascular tube. At the other end the growing uterus is limited by the cirrus-sac and the coil of the vas deferens. In the lateral, most immature part of the uterus that organ appears to be formed by only a very slight modification of the medullary tissue. There is simply an increase in the number of the nuclei, which are thus closer together and become more conspicuous.

Text-figure 3.



Horizontal section through immature proglottid, to illustrate earliest appearance of uterus (*ut.*). *ov.* Ovary.

In the more central parts of the uterus at this stage, which, as already said, is wider, the nuclei are more abundant, both actually and relatively. Between them cavities appear, all of them small but of varying sizes; the dimensions of some coincide very closely with the meshwork of the general medullary parenchyma. The nuclei, at least in many cases, are arranged round these spaces in a regular fashion and thus constitute a lining epithelium to these uterine cavities. The several cavities are separate from each other in this early formed uterus. Fuhrmann * has observed the same mode of origin of the uterus of *Chapmania tauricollis*, and remarks: "Anfangs erscheint der Uterus gekammert."

In later stages there is a confluence of these cavities, and in the fully developed uterus such as is represented in text-fig. 4, the uterus appears to consist of a larger central cavity which is prolonged in all directions through the medullary parenchyma into outgrowths. I am disposed to think that these latter intercommunicate and form a network. In horizontal sections near to the dorsal and ventral surfaces of the uterus the retiform appearance is very strikingly manifested. In transverse sections through the mature uterus the appearance of a number of detached cavities containing ripe eggs is often presented It is, perhaps, this condition which has led to the explanation by v. Linstow * of the clusters of ripe eggs seen in "*Tænia struthionis.*"

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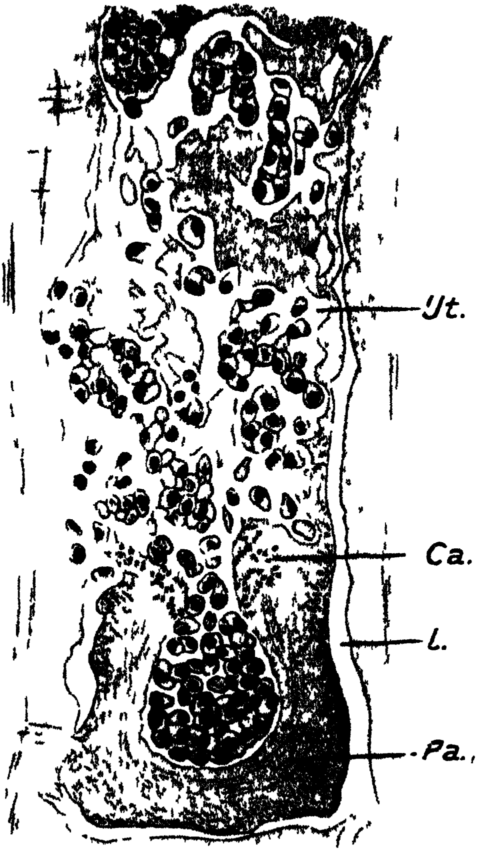
* Rev. Suisse Zool. iv. 1896, p. 121.

Text figure 4.



Horizontal section through mature uterus, showing opening into paruterine organ.

Ca. Mass of calcareous bodies at orifice of uterus. *l.* Lateral water-vascular tube. *Pa.* Paruterine organ. *Ut.* Uterus.

The *paruterine organ* of this species has been figured by

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* Arch. mikr. Anat. xlii. 1893, pl. xxviii. fig. 14.

Zschokke[*] in the course of his description of "*Tænia argentina*," but mistaken by him for a testis, with which identification Monticelli associated himself[†]. Fuhrmann[‡] recognised the true nature of this body, which was certainly puzzling at a time when the paruterine organ, now known in so many Cestodes, was hardly or not at all understood. Zschokke has rightly called attention to the mass of calcareous bodies lying behind the anteriorly placed paruterine organ. The first beginnings of this organ are not plain to me, so little differentiated are at first its tissues from that of the medullary parenchyma of which it is a part. But I feel safe in saying that it does not put in an appearance for some time after the uterus has commenced to develop. I mention this matter as being of importance, since in the species *Rhabdometra cylindrica* the paruterine organ appears before the uterus. There is thus in the present species no obvious connection in development between the two organs. The paruterine organ in a fairly early stage of development lies, as has been stated, anteriorly in the segment and quite close to the anterior edge of the uterus, which is behind it. This surface of the paruterine organ is capped by a rather dense mass of calcareous bodies. The calcareous bodies are not, however, confined to this region of the paruterine organ, or rather to the outside of it; they also occur scattered throughout its substance, but not in such great numbers and not, where present, so closely pressed together. The general outline of the paruterine organ in these not fully mature segments is shown in horizontal sections to be somewhat conical, but with a rather convex base, the latter being anterior in position.

It is, furthermore, to be noted that the paruterine organ is very closely related to the uterus, which lies behind it. The mass of calcareous bodies and the margin of the mass forming the immature paruterine organ are divided by nothing from the uterine cavity. The uterus, that is to say, has no anterior wall save that which is furnished by the paruterine organ. There is thus a distinct relationship between the uterus and the paruterine organ. At this period in its development the paruterine body is solid throughout; there is no trace of a central cavity. In proglottids at the end of the body, which are rather longer than broad and apparently quite mature, the paruterine body has the appearance which is represented in the accompanying figure (text-fig. 4). This is a representation of a horizontal section showing the paruterine body rather oblong in form with rounded angles. It is sharply marked off from the parenchyma of its proglottid laterally. Posteriorly it is not marked off from the cavity of the uterus, that is to say the uterus has no wall of its own dividing it from the paruterine organ. The two structures indeed seem to be mutually differentiated parts of one structure.

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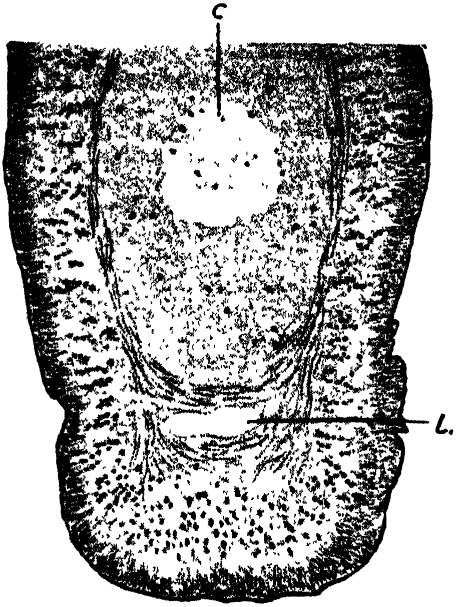
[*] Centralb. f. Bakt. u. Parasit. iii. 1888, p. 1.

[†] Nat. Sicil. xii. 1892–3, p. 208.

[‡] Rev. Suisse Zool. iv. 1896, p. 122.

The paruterine part is about one-third of the total length of the egg-holding receptacle. The walls of the paruterine body are thick, and the fibrous-looking tissue has the strands running along the greater length of the body. Externally it is plainly marked off from the tissue of the medullary part of the proglottid. The mass of calcareous bodies is as plain here as in the younger paruterine organ; but it has got a more definite coherence of its own; the corpuscles are imbedded in a tissue which forms a cap to the paruterine organ and protrudes into the cavity of the uterus behind. The suggestion is that of a valve which, however, hinders the flow of ova into the paruterine organ rather than the converse, which is what would be expected.

Text-figure 5.



Transverse section through mature proglottid, showing paruterine organ.

c. Central cavity of paruterine organ. *l.* Lateral water-vascular tube.

The close relationship of the paruterine organ to the uterus is reminiscent of the conditions which obtain in the not nearly allied genus *Mesocestoides*. In this Cestode, which has been investigated by Hamann *, Fuhrmann †, and some others, the uterus is divided into two regions which form a continuous tube. Posteriorly the uterus acquires thick fibro-spongy walls and serves

* Zeitschr. f. wiss. Zool. 1885.

† Swedish Exped. Egypt, pt. iii.

as the ultimate receptacle of the ripe eggs, being closed to form a spherical capsule. It is this region which suggests the paruterine organ of *Chapmania*, a comparison which Fuhrmann seems, in the memoir quoted, to hold as possible, though Hamann compares this swollen and metamorphosed part of the uterus with a shell-gland (a comparison which seems to be negatived by the discovery of an ordinary shell-gland by Zschokke and others). In no genus, however, is there quite so intimate a connection between the uterus and what is certainly a paruterine organ as in *Chapmania*. It is quite likely that *Mesocestoides* has preserved the original relationship between these parts of the reproductive system.

The access, therefore, of the ripe eggs in the uterus to the paruterine is thus assured; and the drawing to which I have referred (text-fig. 4) shows this movement in progress. The eggs occupy the central hollow region of the paruterine organ, and are to be seen in transit in various parts of the same and of the uterus. I have observed eggs entangled, as it were, in the lax tissue forming the plug of calcareous bodies[*]. There is no doubt but that here the transference of ova to the paruterine from the uterus is quite direct. They could hardly reach it by another route, in view of the free continuity of the two sacs.

Nevertheless, another view has been advanced by Fuhrmann[†]. In his important résumé of the genera of Cestodes found in birds, this author remarks in the definition of the genus *Chapmania*—"Die Eier gelangen in einen stark verzweigten Uterus und von da wie bei *Davainea* in Parenchymkapseln, worauf sie in abgelösten Gliedern in ein am Vorderrand gelegenes breites, grosses Paruterinorgan gepresst werden, das eine Kapsel um sie bildet." This definition is accepted by Ransom, who practically translates it in his general survey[‡] of the Cyclophyllidea. In a later and fuller table of distinctions of the genera of Davaineidæ[§] this is altered. In the latter, Ransom says (as part of his definition of the genus *Chapmania*), "Eggs pass anteriorly into a paruterine organ from the uterus either directly or after the disappearance of the uterine wall and the envelopment of the eggs in individual parenchymatous capsules." This alternative statement as to the fate of the ova is apparently due to an earlier definition by Fuhrmann of the genus *Chapmania*[||], which runs (so far as concerns the matter under discussion) as follows—"Die Eier, statt im Parenchym zu zerstreuen, in ganz reifen losgelösten Proglottiden in einem parenchymatösen Paruterinorgan, das zu einer Uteruskapsel wird, vereinigen." I believe, however, that this definition was made to include the species described in that memoir as *Chapmania longicirrhosa*, a species which Fuhrmann later * transferred to the genus *Idiogenes*, and to the species *I. flagellum*.

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[*] It may be pointed out that, in his figure of *Chapmania longicirrhosa* (later regarded as identical with *Idiogenes flagellum*), Fuhrmann (Centralb. f. Bakt. u. Parasit. Bd. 41, p. 81, fig. 3) represents a mass of calcareous bodies such as occurs in *Chapmania tauricollis*, but upon the opposite side of the paruterine organ, *i. e.* upon its anterior face. If this be not an error there is perhaps here an additional point of distinction between the two genera.

[†] Zool. Jahrb. Suppl.-Bd. x.

[‡] Bull. U.S. Nat. Mus. no. 69, 1909.

[§] "A New Cestode from an African Bustard," Proc. U.S. Nat. Mus. vol. xl. p. 646, 1911.

[||] Centralb. f. Bakt. u. Parasit. Bd. 41, 1906, p. 83. This memoir, however, is not quoted by Ransom, which is merely an oversight, as he refers to it in a footnote enumerating the synonyms of *Idiogenes flagellum*.

I have been quite unable to find a trace of anything like the "Parenchymkapseln" of *Davainea* or any other genus in which such structures exist. Nor do I think that it would be easy to miss such bodies were they, at any rate, so conspicuous as in the genera which are known to possess them (e. g., *Inermicapsifer*, etc.). My figure is, as I think, decisive as to the direct entry of the ripe ova into the paruterine organ; in no other possible way can the facts observed, and there represented, be explained. I can only suggest that the irregular form of the uterus in ripe proglottids, as I describe it later, may be responsible for the statement that the eggs are separately envolved in parenchymatous capsules before being pushed into the paruterine organ. For in many sections ova may be seen to lie apparently in closely fitting capsules, these being in reality the expression of the ramifying branches of the uterus. Or it may be that both methods occur in this species, or finally, there is the possibility, which I do not consider to be very great, that the worm which I deal with in the present communication is not *Chapmania tauricollis* but a new form.

The last word about the paruterine organ of this Cestode is contained in Fuhrmann's account of *Chapmania tapica* †. Here that author states that "Bei *Chapmania* (auch bei *Chap. tauricollis*) geschieht dieser Uebertritt der Eier erst in abgelösten Gliedern und ist deshalb von andern Autoren noch nie beobachtet worden." It is clear, from my own observations, that the eggs reach the paruterine organ at an earlier period. I think, however, that in my species, *Otiditænia eupodotidis*, plainly belonging to this subfamily, this late transference does occur.

Systematic Position of Chapmania tauricollis *and validity of genus* Chapmania.

There is, of course, no need to argue the position of this tapeworm so far as concerns its family and subfamily position. It is clearly a member of the subfamily Idiogeninæ of the family Davaineidæ.

This subfamily contains three genera, viz., *Idiogenes*, *Chapmania*, *Sphyronchotænia*, and very possibly my genus *Otiditænia* ‡. The most recent survey of the characters of the three former genera is by Ransom *, who distinguishes the three by the following salient characters—which I withdraw from his fuller diagnosis:—

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* Zool. Jahrb. t. cit. p. 50.

† Swedish Exped. Egypt, pt. iii. p. 23.

‡ See P. Z. S. 1912, p. 194, and ibid. 1914, p. 879.

Idiogenes.—Small worms with weak musculature. Genital pores unilateral (except in *I. otidis*). Suckers unarmed. Cirrus-sac large. Eggs pass directly into paruterine organ.

Chapmania.—Larger worms with strong musculature. Genital pores unilateral (in *C. tauricollis*). Suckers armed. Cirrus-sac not large. Eggs first developed in separate egg-capsules and then passed into paruterine organ.

Sphyronchotænia.—Larger worms with strong musculature. Genital pores unilateral. Suckers unarmed. Cirrus-sac not large. Eggs pass directly into paruterine organ †. Many rows of hooks on rostellum.

We may leave aside *Sphyronchotænia*, which is clearly a separate genus—not to be confounded with either *Idiogenes* or *Chapmania*. With regard to the two latter the differentiation deducible from the above characteristics is altered to some extent by the new facts recorded in the present communication. In the first place, the cirrus-pouch of *Chapmania* is not particularly small as is alleged by Ransom. I take it that the American helminthologist has been misled by the absence of any statement about the cirrus-sac of *Chapmania* in Fuhrmann's definition of the genus, while, on the contrary, *Idiogenes* is defined by a large sac. But the latter author, in his description of "*Davainea tauricollis*," remarks ‡ that the cirrus-sac reaches to the middle of the proglottid, a statement which I confirm from my own observations §. There is, therefore, here no difference between *Idiogenes* and *Chapmania*. I have discussed above, in detail, the statement that *Chapmania* differs from *Idiogenes* in the fact that the former genus shows a series of egg-capsules in which the ova are imbedded before their transference to the paruterine organ, and shown that there is no such difference between the genera. There remains, therefore, merely the difference of size and the stouter build of *Chapmania*, which is caused by the relatively and actually greater thickness of the longitudinal muscular layer of the body, to form a basis of distinction from its ally *Idiogenes*. It is not at all impossible to regard these facts as of generic value; but it must be remembered that variations in the longitudinal musculature are by no means always accompanied by other structures which imply undoubted generic difference among the Cestodes. It is possible, however, that a simple sac-like form of uterus characterises *Idiogenes*[*].

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* Proc. U.S. Nat. Mus. vol. xl. 1911, p. 637.

† This is to be inferred, as the actual transference was not seen in any of its stages by Ransom.

‡ Rev. Suisse Zool. iv. 1896, p. 119.

§ But the exact point to which the cirrus-sac reaches is affected by the degree and direction of the contraction of the particular proglottid examined. It is possible that the generic distinction has been chiefly founded upon *Chapmania tapica*, where, according to Fuhrmann (Swedish Exped. Egypt, pt. iii. p. 23), the cirrus-sac hardly reaches the water vascular vessel.

I should be, on the whole, disposed to define the genera of the subfamily Idiogeninæ as follows:—

Subfamily *IDIOGENINÆ*.

A single paruterine organ present in the ripe proglottid.

A. *Ten to twelve rows of hooks on the rostellum.*	*SPHYRONCHOTÆNIA. — Suckers unarmed. Genital pores unilateral. Longitudinal muscles thick. Dorsal water-vascular trunk absent in posterior proglottids. Testes numerous, extending far anteriorly. Uterus divided into chambers, larger than paruterine organ. Eggs transferred late to paruterine organ. Cirrus-sac small.*
B. *Two rows of hooks on the rostellum.*	*OTIDITÆNIA.—Suckers unarmed. Genital pores alternate. Longitudinal muscles thick. Dorsal water-vascular trunk present in posterior segments. Testes numerous, posterior. Uterus divided into chambers, extends dorsally into cortical layer, much smaller than paruterine organ. Eggs transferred late to paruterine organ. Cirrus-sac small.*
	CHAPMANIA[†]*.—Suckers armed. Genital pores alternate. Longitudinal muscles thick. Dorsal water-vascular vessel absent in posterior proglottid. Testes numerous, posterior. Uterus divided into chambers, which in mature uterus communicate and form a network, larger than paruterine organ. Eggs transferred early to paruterine organ. Cirrus-sac large.*
	IDIOGENES[‡]*.—Suckers unarmed. Genital pores unilateral or alternate. Longitudinal muscles slight. Testes few, posterior. Uterus not divided into chambers, larger than paruterine organ. Cirrus-sac very large.*

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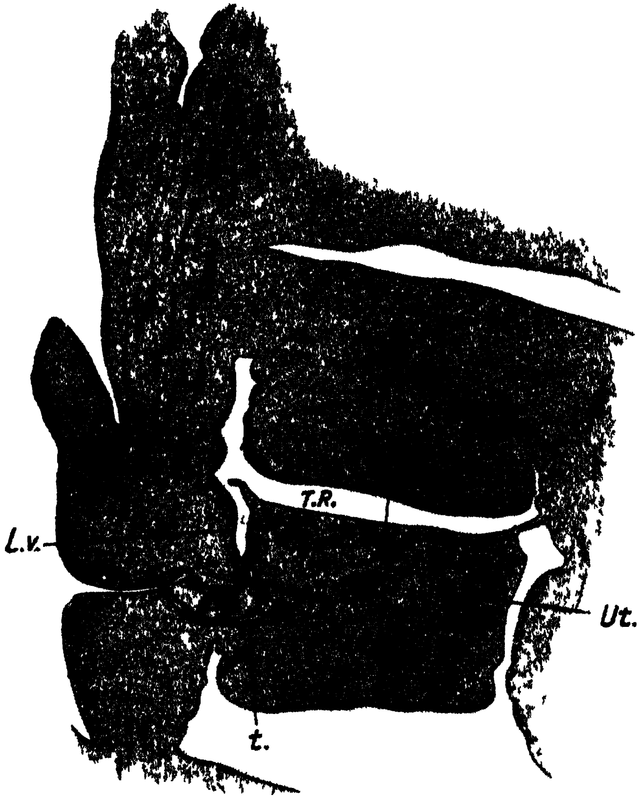
[*] See also footnote to p. 438 for another possible generic distinction.

[†] In view of the network which the sperm-duct forms and the tentacles upon the scolex, I exclude for the present *C. tapica* from the above genus.

[‡] It will be noted that the feebly developed longitudinal muscular system, the small number of testes, and the simplicity of the uterus may be correlated with the small size of the species of this genus.

I may point out, in conclusion, that the subfamilies Idiogeninæ and Davaineinæ, have corresponding relations to Cestodes commonly referred to different families by reason of their lack

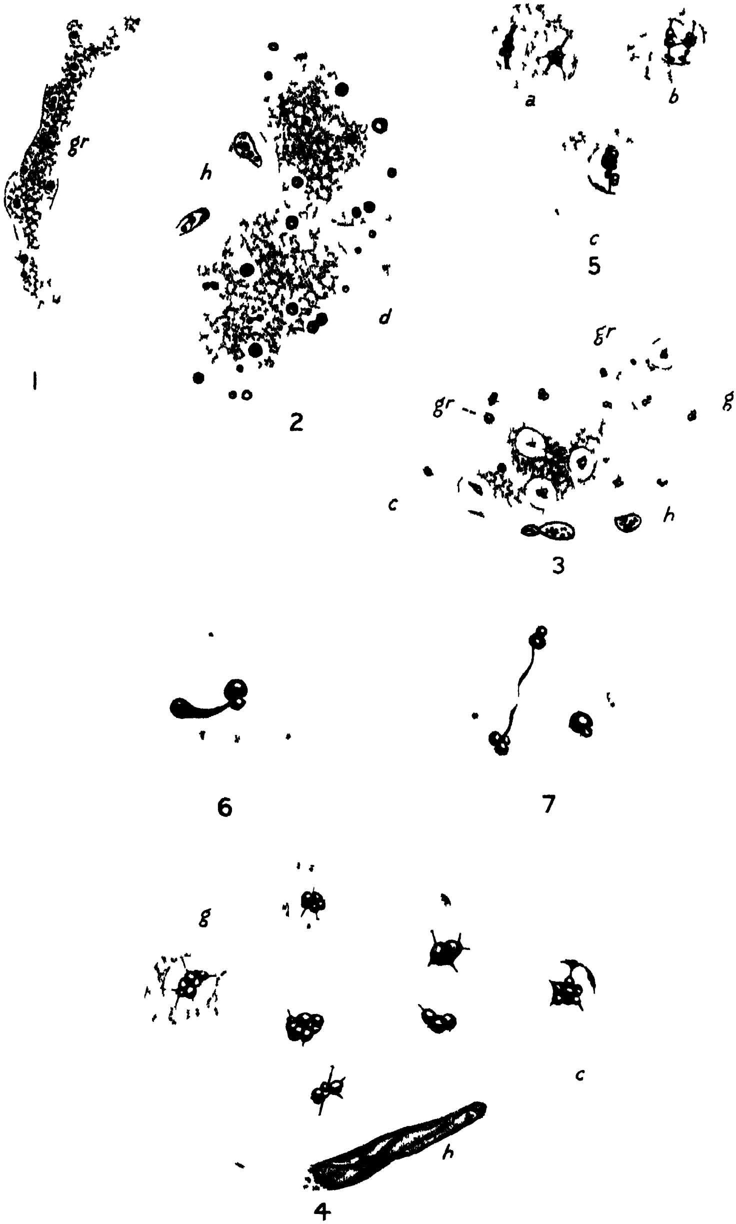
Text-figure 6.



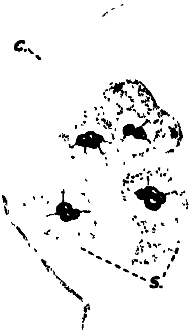
Horizontal section through immature proglottids, showing position of gonads.

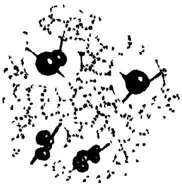
c. and *t.* Cirrus-sac. *l.v.* Lateral water-vascular tube. *o.* Ovary. *Ut.* Testes more thickly disposed on the side away from the pore. *T.R.* Transverse water-vessel. *v.g.* Vitelline gland.

of rostellar hooks. There is, for instance, a close resemblance between *Rhabdometra* and its allies and *Idiogenes*, which possesses a single paruterine organ, on the one hand, and between *Zschokkeella* and *Inermicapsifer* and *Davainea*, with many "egg-capsules," on the other. In these instances the loss of the rostellar hooks would need the reference of *Davainea* to either *Zschokkeella* or *Inermicapsifer*, and of *Idiogenes* to *Rhabdometra* or one of its near allies. The relation is quite like that between *Tæniarhyncha* (*sens. strict.*) and *Tænia*. In *Tæniarhyncha*, a genus formed to include the hookless *Tænia saginata*, we have a typical *Tænia*, differing only by the character mentioned and the correspondingly reduced rostellum. It is, therefore, very important to ascertain positively the presence or absence of rostellar (and other) hooks in view of the above relations. This task is—my experience with *Chapmania* teaches me—not always easy. I have carefully re-examined the scolex of my species *Zschokkeella gambiana* in order to set doubts at rest. I am still unable to find hooks thereon, and cannot, therefore, alter my opinion of its systematic position.



MINCHINIA





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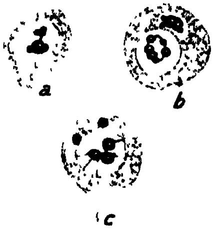

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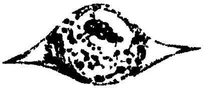

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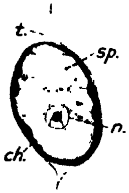

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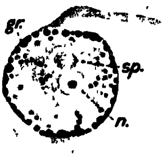

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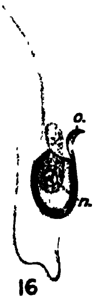

16

MINCHINIA.

34. *Minchinia*: A Haplosporidian. By Helen L. M. Pixell-Goodrich, B.Sc., Beit Memorial Research Fellow *.

[Received April 9, 1915: Read May 11, 1915.]

(Plates I. & II.†)

The genus *Minchinia* (Labbé) undoubtedly belongs to the Haplosporidia, although it has invariably been placed among the Coccidia. Schaudinn (**17**, p. 276) went so far as to include the genus in that of *Adelea*, and in this he was followed, tentatively only, by Doflein (**7**, p. 744).

Minchinia chitonis Lankester is the only well-established species; other so-called species will be dealt with later. This parasite was first recorded so long ago as 1885 by Lankester (**11**, fig. 12), who found it in the liver of *Chiton* and gave a drawing of the spore under the name of *Klossia chitonis*. Labbe (**9**) examined the same parasite in 1896, and, recognising its distinctive characteristics, made it the type species of a new genus, which he named *Minchinia* in honour of Prof. Minchin. The spore has a thick chitinous coat and an outer membranous envelope produced into a long tail at either end.

In 1897 Leger (**13**) described a new Coccidian *Barroussia caudata* whose spore was said to be provided with a long tail at one of its poles, though, so far as I can make out, it has never been figured. In a subsequent communication Leger (**14**, p. 7 footnote) pointed out that this form, parasitic in *Lithobius martini*, had affinities with *Minchinia*, though he did not recommend connecting the two forms. In spite of this, Labbe in 1899 (**10**) included this species of *Barroussia* in his new genus as *Minchinia caudata*. In 1898 Léger (**15**) described the flagellated microgamete belonging to this species, which is undoubtedly Coccidian in type. Therefore *Barroussia caudata*, a true Coccidian, is no longer to be included in the genus *Minchinia*.

Patella and *Trochus* were also given by Labbé as hosts of *Minchinia*, although he seemed undecided whether or not these contained the same species as *Chiton*. No figures of these parasites were given except one of a trophozoite from *Patella* which appears to be Coccidian in character. Therefore it seems likely that this *Patella* parasite may also turn out to have no relationship with *Minchinia*. The specimens of *Patella* and *Trochus* that I have examined have not been infected at all, although some specimens have been taken from exactly the same locality as infected *Chiton*.

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* Communicated by the Secretary.

† For explanation of the Plates see p. 450.

OCCURRENCE OF *MINCHINIA* IN *CHITON*.

During the last four or five years I have searched Chiton from Plymouth and other parts of the British coast, as well as from parts of the Pacific and Mediterranean, for traces of this parasite, and it was only in October last that specimens of Chiton at Plymouth were found to be strongly infected. The species of Chiton so parasitised was *Craspedochilus cinereus* (Linn.)* from Rum Bay, not *Acanthochites* (*Chiton*) *fascicularis* (Linn.), stated by Labbé to be the host at Roscoff. In fact the latter species I have never found to be infected. From this locality, out of 135 specimens of *Craspedochilus cinereus* examined, 85 have had a more or less advanced infection. This proportion of infected specimens, roughly two-thirds, does not coincide with Labbé's description of *Minchinia* as a rare parasite. However, these figures only refer to specimens of *Craspedochilus cinereus* from a small stretch of coast near Plymouth called Rum Bay. Perhaps the best ground for the collection of Chiton in the Plymouth district is the mouth of the river Yealm; here, however, the specimens are small only, and out of twenty-five not a single one has been found to be infected with *Minchinia*. Chiton (two only) examined from Wembury Bay have also been free from infection.

The infection is thus shown to be very localised; whether the Chiton in Rum Bay are suffering from an epidemic of this parasite, or whether *Minchinia* is endemic to this locality, could only be determined by an investigation extending over several years.

The parasites have so far only been recorded from the liver; they are, however, not restricted to this organ, but later overrun all the connective tissue. They are especially numerous between the lobes of the liver and the interior projections of the walls of the so-called sugar-glands (Zuckerdrüsen). Infection then spreads to the wall of the gonad, radula sac, gills, and blood-spaces in the foot. Cases of advanced infection can nearly always be detected without dissection, because cysts full of spores can be seen in the gills and through the epidermis of the foot.

In such favourable positions, lying immersed in the host's blood, the parasite has every opportunity of nourishing itself, and during its rapid endogenous multiplication the liver becomes gradually deprived of its reserve food materials. In early cases of severe infection the presence of numerous colourless plasmodia and young cysts gives a white appearance to the liver, which is normally brownish. As the cysts become filled with brown chitinous spores they appear black by reflected light, and consequently a liver with a severe infection at an advanced stage is quite black, as well as being enormously enlarged owing to the bulk of parasites between the lobes. The liver-cells in such advanced cases were found to have lost their reserve food and to be much reduced in size. In spite of the necrotic condition of this organ, however, the life of the Chiton appeared to be little affected—at any rate, in captivity infected specimens sometimes lived longer than non-infected. No observations appear to have been made on the normal length of life of a Chiton, possibly it may be great. Quite small specimens are often sexually mature; on the other hand, strongly infected specimens are nearly always very large—some of them the largest specimens ever seen at Plymouth. Could it possibly be that development of *Minchinia* in a Chiton causes the whole animal to hypertrophy! On the whole, adult forms were better infected than young ones, as would be expected. I have not seen the earliest stages of infection, but presumably the Chiton become infected when feeding: they are said to be entirely vegetarian. Labbé has figured three (**10**. text-fig. 107) so-called sporozoites in the liver-cells; possibly one of them is something of the kind, the other two appear to be the normal contents of the liver-cells. Many experiments by which I have tried to infect Chiton artificially have given negative results. Ripe spores have not been induced to open when introduced into the œsophagus or placed in fluid from different regions of the alimentary canal. Therefore we seem forced to the conclusion that there is another host; this, at the beginning, seemed unlikely: first, because the spores as developed in Chiton are so admirably adapted for an external free existence, and secondly, it is not easy to see how such an animal as Chiton, which feeds on plants, could easily become infected from other animals. Certain other facts in this connection are given below after the description of the spores.

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* [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.]

METHODS.

Bouin's picro-formol-acetic mixture was found to be the best fixative for infected tissue, since this penetrates to a certain extent even into ripe spores. The special methods applied to these spores will, however, be described later when considering their structure. For general purposes picro nitric and corrosive sublimate mixtures were also satisfactory. Owing to the small size of gametes, sporoblasts, and young spores, it was necessary to have thin sections (3 4 μ), and when there were many chitinous spores this was not easy. Breaking of sections was sometimes prevented by painting with collodion. For following the development of the spores it is essential to have living material, and methyl-green and acetic acid mixture was used for temporary preparations. Numerous coverslip films and smears stained with Giemsa were also used for studying the development. For staining films and sections iron hæmatoxylin or hæmatein methods are of course most useful; water solutions certainly seem to give better results than the alcoholic ones recommended by Lee (**12**, p. 156) and others, though by the latter staining is more speedily effected. The chitinous substance forming the spore coat stains very intensely by these methods, which are therefore not always convenient. In these cases Ehrlich's, Mann's, or Delafield's hæmatoxylins have given better results. Carmine stains have always proved disappointing. As a rule counter-staining was not found to be an advantage, the cytoplasm being sufficiently stained by the hæmatoxylin.

PLASMOTOMY.

All Chiton examined from October 1914 to April 1915 were heavily, if at all, infected. In only two cases was endogenous multiplication still proceeding, and these specimens were obtained and fixed during October. One of these (Chiton V) contained also many stages in sporogony and even some ripe spores; the other (Chiton X) was crowded chiefly with plasmodia, which gave a white appearance to the liver. Most of the plasmodia were irregular in outline, but they varied much in shape and size (Pl. 1. figs. 1 & 2). Scattered through them were nuclei consisting of masses of chromatin, round each of which could be distinguished a clear space. At this stage the nucleus has no sign of a membrane. Frequently these nuclei were dividing by a simple method of mitosis. In vain have I searched through hundreds of sections to find any trace at this stage of the beautiful spindles which have been figured for some Haplosporidia (**2**) (**18**). Swarczewsky states that Chatton (**5**) must have missed them in *Caullerya mesnili*; but such does not necessarily seem to be the case, for I do not think that they can have been passed over in *Minchinia*.

When about to divide, the mass of chromatin separates into two parts, which gradually move away from one another, but for some time are connected by a slender thread (centrodesmose). It has not been possible to demonstrate the centrosomes contained in these chromatin masses by means of differential staining, although one would expect them to be present.

When a plasmodium has attained a certain size, or from other causes, it breaks up into daughter plasmodia, each with several nuclei (fig. 2). All these trophic stages are quite naked and their outlines generally irregular. It seems clear that they flow along to some extent, probably only very slowly, by putting forth pseudopodia. Sometimes between closely apposed lobes of the liver a plasmodium becomes very elongated and narrow (fig. 1). No doubt want of space often determines the breaking up into daughter plasmodia. It is rare to find one longer than 100 μ or wider than 50 μ.

During this endogenous multiplication of the parasite the host's phagocytes become very active and multiply rapidly, sometimes forming clumps. They appear to make a vain attempt to engulf the parasites, and occasionally one is observed flattened against a plasmodium.

There is a certain amount of evidence to show that solid particles can be ingested by the plasmodia as by an ordinary amœba. Masses of fibres staining black with iron hæmatoxylin may sometimes be seen enclosed in an active plasmodium. They either disappear before encystment, or sometimes they may be extruded in a mass directly after the formation of the cyst, and become compressed between it and the parasite. Further, certain deeply staining granules are generally contained in the cytoplasm, round which no clear space can be observed as round a nucleus. These granules are easily distinguished from nuclei when the latter assume the vesicular form after encysting (Pl. I. figs. 1 & 3, *gr*), although it is almost impossible to distinguish them before this change is affected. Caullery and Mesnil (**2**, fig. 11) saw similar chromatic bodies left over after the nuclei had become vesicular, but interpreted them as degenerate nuclei. In *Minchinia* they seem likely to be unassimilated particles, possibly remains of host-cells, taken in during the active life of the plasmodium. In one case it was practically certain that the parasite had ingested a host-cell —apparently a phagocyte! In many cases these cells apply themselves so closely to a plasmodium that it is difficult to see any boundary between them (fig. 2). Cuénot (**6**) has recently given some useful information about the activities of the phagocytes of *Chiton*, and usually there is no difficulty in distinguishing the nucleus of one of these cells from a parasite nucleus. In *Minchinia*, however, certain plasmodia occasionally appeared at first sight to be giving off buds in which the nucleus had assumed a vesicular form; but after further study I am convinced that these specimens were really only plasmodia to which host-cells were endeavouring to attach themselves. Gemmation has, however, been described by Swarczewsky (**18**) as a mode of reproduction, in addition to plasmotomy, in certain Ichthyosporidia.

SPOROGONY.

(1) *Formation of gametes.*

When the host has become strongly infected most of the plasmodia draw in their pseudopodia and become rounded off and encysted. It seems possible, from the consideration of after-events, that two plasmodia may mingle before encysting, but no direct evidence has been forthcoming on this point. A thin pellicle is secreted, but in most cases this is soon covered and obscured by the host's amœbocytes, which apply themselves to it, becoming gradually flattened out to form a cellular cyst around the parasite. This cyst is generally only one cell thick (Pl. I. figs. 3 & 4), and its nuclei become more and more flattened with growth. Occasionally there may be four or five layers of cells forming a thick cyst round a parasite, but this is an abnormal condition. The cysts are spherical, and vary very much in size, but they are not generally more than 75 μ, or less than 40 μ, in diameter. The nuclei assume a vesicular form, and probably enter upon a resting stage. This change is affected by the breaking up of a mass of chromatin into granules, some of the smaller ones of which pass to the periphery, where a distinct membrane appears. The central chromatin generally forms two or three distinct masses, often connected with the membrane by fine strands. These vesicular nuclei are more or less oval, and their longer diameters are slightly less than 3 μ.

Occasionally, forms have been seen in which the nuclei are massed in the centre, leaving a clear peripheral border of cytoplasm. In addition there is sometimes a cavity in the middle, but the nuclei are not arranged in a definite single layer round this cavity as described by Alexeieff (**1**. p. 36, fig. 4) for his "plasmodes blastuloides" in *Ichthyosporium gasterophilum*. In *Minchinia* the occurrence of the central cavity, at any rate, appears to be an artifact.

When preparing to divide a nucleus of this vesicular type increases in size and a bundle of achromatic threads appears along the greatest diameter acting as a kind of spindle. The chromatin, after arranging itself on this spindle, is drawn to the poles. The vesicle then constricts in the middle, and the two ends are finally nipped off as daughter nuclei. This process has been beautifully figured by Granata (**8**, Plate 3) for *Haplosporidium limnodrili*, in which, according to the magnification given, the nuclei are considerably larger than those of *Minchinia*.

After a time the cytoplasm separates and collects round these nuclei either singly or sometimes in clumps of from two to seven or eight. Occasionally a dozen or so different sized masses have been seen inside a cyst and have been set free by bursting it. When compressed, these masses are seen to contain varying numbers of nuclei. Ultimately, however, such multinuclear masses are resolved into uninuclear bodies which appear at times to be distinctly amœboid. These are the gametes. No residuum is left over except the chromatoid granules, which do not become transformed into vesicular nuclei as already described.

(2) *Syngamy and formation of zygotes.*

The gametes proceed to pair. Fusion of their cytoplasm first takes place to form a single body with still separate nuclei (Pl. I. fig. 5 *a*) for which the term Prozygote has been proposed (**16**). Caullery and Mesnil (**2**) hesitated to give a definite opinion as to whether similar bodies with two nuclei in some of their Haplosporidia represented forms undergoing division or gametes undergoing syngamy, because they also found masses with four nuclei in some cases. The same difficulty presents itself in *Minchinia*; but, after prolonged study of living stages and careful measurements of the different sized bodies and nuclei contained in cysts, the above seems the only possible interpretation. Caullery and Mesnil's forms with four nuclei (**2**, fig. 43) seem to be stages in the formation of the sporoblasts as described below (figs. 7 & 8).

After some time has elapsed the gamete nuclei in the prozygote approach one another (fig. 5 *b*) and fuse to form the syncaryon (fig. 5 *c*). The zygote so formed appears to be produced by autogamy. Such may not be really the case, however, for it is quite possible that the gamete nuclei may have been derived from distinct parents. Either two plasmodia during their wanderings may have come together and their cytoplasm fused before encystment (plastogamy), or there is some evidence in other Neosporidia to show that the amœbulæ fuse in pairs on their escape from the spore. In the latter case probably their nuclei do not fuse but divide independently, and ultimately syngamy takes place between gamete nuclei formed in equal numbers from each parent.

(3) *Formation of spores.*

The zygotes generally proceed almost at once to divide twice (Pl. I. figs. 6 & 7) to give four sporoblasts: division is effected here again by a simple method of mitosis. As a rule, the nuclei go through both their divisions before the cytoplasm divides, so that the stage with four nuclei (Pl. II. fig. 8) is quite common, but sometimes division of the cytoplasm follows after the first nuclear division. Also, these divisions are not always simultaneous even in one and the same cyst, therefore there may be enclosed together with free sporoblasts masses with two, three, or four nuclei, and even an undivided zygote. This fact added much to the difficulty of elucidating the life-history of *Minchinia.*

The sporoblasts when first separated are very small and their protoplasm rather vacuolar. They soon begin to secrete a membrane which is produced into a short tail at either end (Pl. II. figs. 10 & 11). The young spore then grows considerably: presumably the membrane is so thin that it does not prevent the absorption of food. While still quite small its nucleus divides, giving off a parietal mass of chromatin (figs. 9*a* & 9*b*) which sometimes divides into two (fig. 9*c*) These parietal nuclei or masses of chromatin, for possibly they are not true nuclei, are very distinct at this stage. Their prominence, however, is very transitory, for soon after they are masked by numerous other chromatic bodies which are given out by the main nucleus. Probably the parietal "nuclei" themselves also break down into similar chromatic granules or globules. These are highly refringent and pass to the periphery, where they arrange themselves to form the chitinous spore coat, as will be more fully explained later.

At the stage when these globules are passing out in a centrifugal direction there arises in the cytoplasm, near the nucleus, a homogeneous finely granular spherule (Pl. II. fig. 14). I have no evidence that this comes actually from the nucleus as described by Granata (8) for *Haplosporidium limnodrili.* The spherule is distinguished by the fact that it stains only slightly and takes up its position just underneath the operculum. Unripe spores open fairly easily when treated with certain reagents, methyl-green acetic mixture for example. From a young spore under these conditions the spherule makes its way out as soon as the operculum is raised. Similar bodies have been mentioned as occurring in many Haplosporidia. In *Minchinia* the spherule is very large at the stage when the spore coat is nearly completed (figs. 13 & 14), and after this appears to gradually diminish, until in the ripe spore it is generally not to be distinguished at all. Possibly it is composed of some kind of reserve food on which the developing spore can feed as soon as it is cut off from the outer world by the formation of its thick chitinous coat.

During the deposition of the substance which forms the chitinous coat there is a considerable shrinkage of the nucleus (figs. 12, 13, 14). Although the substance appears to come directly from the nucleus it is not presumably similar to chromatin in composition. In the living it is more refringent. When the globules, which arrange themselves at the periphery just inside the spore membrane (fig. 14), are sufficiently numerous they begin to run together. Ultimately a continuous layer one micron in thickness is formed all round the spore (figs. 13 & 15). This is at first colourless, but later becomes light brown but remains translucent. In its behaviour to certain stains this substance also differs from chromatin. Although it stains densely black with iron hæmatoxylin and red with saffranin, the more selective nuclear stains such as Ehrlich's, Mann's, and Delafield's hæmatoxylins do not stain it nearly so intensely as chromatin. In Giemsa preparations the membranous covering of the spore generally stains red and the inner chitinous coat blue, not red like the nucleus.

The chitinous substance is very resistant: like true chitin, it is not dissolved by boiling in strong caustic potash (30 °/₀); but, on the other hand, it does not acquire the characteristic mauve colour shown by chitin with the iodine in potassium iodide and zinc chloride test. Thus it must be concluded that while closely resembling, it is not identical with ordinary chitin.

(4) *Spores.*

The ripe spores vary a good deal in size but are always oval, and when living generally about 10 μ long and 6 μ wide. The largest measured was 13 μ long and 8 μ wide. The latter giant spores seem to be distributed promiscuously; that is, there is no distinction of cysts into those containing macrospores and microspores. Normally the tails into which the outer membrane of the spore is produced are about four times the length of the spore, but they are more or less brittle, and often become broken off. The chitinous coat is thick and very resistant. It can be softened in various ways, *e.g.* immersion in Eau de Javelle or weak formalin, in order to make it sufficiently permeable for its contents to be stained. Formalin (4 °/₀ formaldehyde) is especially good for this purpose, and when followed by Ehrlich's hæmatoxylin enables the spore nucleus to be well stained. Prolonged immersion in distilled water had no apparent effect on the spore. Iodine stained the chitinous coat yellow but otherwise had no result. Adult spores were occasionally induced to open by pressure and reagents combined (Pl. II. fig. 16). The operculum always opened away from the tail and turned inside out, but remained attached by the outer membrane, which acted as a hinge.

Apparently the spores of *Minchinia* are set free only by the death of the host.

From the structure of the spore one would expect it to be destined for a prolonged free existence in sea-water. It has been proved experimentally that the spores can remain for months apparently unchanged in water, and can also undergo drying to some extent. No success, however, has been obtained in attempts to make them infect other Chiton directly. Living spores have resisted all attempts to make them open. On some occasions spores have been introduced into the œsophagus of a Chiton by means of a very fine pipette; on another occasion a few spores in a tiny piece of blotting paper tied with a fine silk thread were introduced into the œsophagus of an uninfected Chiton, but on removal after several hours were found to be quite unchanged. At other times spores, after being in sea-water, have been mounted with teased portions from different regions of the alimentary canal, all with no result. One such preparation sealed up on November 27th, and another on December 18th, lost all bacterial infection after a few days, and were on March 22nd quite sterile with the spores unchanged.

Uninfected specimens of Chiton were also kept during March and April under conditions as normal as possible except for the presence of numerous spores of *Minchinia* in the water. Although the Chiton ate the fucus to which spores easily adhere, they did not become infected during seven weeks nor were any spores found in their alimentary canals *.

Attempts were then made to infect other animals from the rocks at the same zone with the spores of *Minchinia*, as it was thought that possibly shore fish, etc. might become infected in this way with another vegetative stage of *Minchinia*. Owing to the courtesy of the Director, these experiments have been carried on in the Marine Biological Laboratory, Plymouth, and I am indebted to Mr. A. J. Smith for much valuable assistance. In each case stones with several Chiton attached were introduced into large tanks through which water was circulating and containing the animals being experimented upon. The results of these experiments were as follows: –

1. *Blenny.*—These fish attacked the Chiton readily. All stages

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* See note at end of paper.

of *Minchinia* were digested except the ripe spores, which pass through unchanged. It is of interest to notice that the shell of the Chiton passed through undissolved, the eight plates reappearing generally unbroken in the fæces, whereas in the case of *Pomatoceros*, which is also readily torn from the rocks and devoured by the Blenny, the portions of tube eaten were softened if not entirely dissolved. This difference is, no doubt, due to the greater proportion of insoluble organic matter in the Chiton shell.

2. *Rockling.*—Chiton left undisturbed for 7 days.
3. *Goby.*—One Chiton bitten off, but none eaten during 8 days.
4. *Motella.*—Chiton left undisturbed for 12 days.
5. *Crab* (*Carcinus mænas*) devoured Chiton readily. All stages of *Minchinia* were digested except the spores, which passed through unopened. The tails of the spores were often broken, for, as a rule, the spores were freed from their cysts.
6. *Purpura.*—Chiton left undisturbed for over a month.
7. *Star-fish* (*Asterias glacialis*)—6 Chiton out of 8 eaten in 10 days. *Minchinia* spores found in alimentary canal showed no signs of opening.
8. *Sea-Urchin* (*Echinus miliaris*).—Chiton left undisturbed for 13 days.

The passage of the spores through the alimentary canal of the Crabs and Blennies lasted at most three days. Doubtless in this way they are disseminated, but they do not appear to be changed. Experiments to induce spores, recovered from the fæces, to open in the digestive fluids of Chiton were no more successful than with fresh spores.

From the description given above it will be clear that *Minchinia* has affinities with *Urosporidium* and *Haplosporidium* and belongs to the family Haplosporiidæ of Caullery & Mesnil (**2**), which Léger and Duboscq (**15a**) also recognise as a well-defined group. There is therefore no need to enter here into the controversy as to whether the Haplosporidia taken as a whole, as conceived by Caullery and Mesnil, is a rational group. Doubtless, as these authors were well aware, some rearrangement will be necessary when more is known as to the life-history of these strange forms. Cépède (**3** & **4**) in 1911 and 1913 briefly described a curious Haplosporidian from *Donax*, unfortunately without giving any figures; owing to the presence of a surrounding cell in the young spore he seemed to think that the term Haplosporidia (ἁπλοῦς, simple) was not suitable, and suggested renaming the group Acnidosporidia. There appears to be no need for such a procedure, the *Donax* parasite and also *Minchinia*, in which the young spore likewise shows an indication of a parietal nucleus, have simple spores in comparison with those which possess polar capsules. At any rate it seems most inadvisable at present to encumber with new names and classifications the already complicated literature of these forms when the majority of their life-histories have never been at all satisfactorily investigated.

Summary.

1. The genus *Minchinia* is here shown to belong to the Haplosporidia, instead of to the Coccidia, among which it has been placed since it was established by Labbé in 1896.

2. Its life-history in Chiton consists of two stages, a trophic and a sporogonic.

3. During the trophic stage a multinucleate individual divides by a process of plasmotomy.

4. During the sporogonic stage a plasmodium becomes encysted, forms gametes, which fuse in pairs (? autogamy, see page 451) to give zygotes. The zygote breaks up into four sporoblasts, each of which acquires an external membrane drawn out into a tail at each end, and later a thick chitinous coat immediately inside the membranous one.

5. Crabs, Blennies, and Star-fish eat Chiton, but the spores of *Minchinia* pass through unchanged, and are in this way disseminated.

The Museums,
Oxford.

P.S.—Since writing the above many Chiton have been kept here in Oxford with free spores of *Minchinia* in aerated sea-water. After three or four weeks numerous unopened and unchanged spores, often enclosed in fæcal pellets, were found in the intestine of several of the Chiton. These, which included uninfected and previously infected specimens, were carefully examined and some were cut in serial sections, but in no case did the spores show any sign of opening. All organs of the specimens not previously infected were quite normal.

This failure of the spores to open when eaten naturally by Chiton, confirms the negative results obtained in the above experiments, and we seem forced to the conclusion that the spores of *Minchinia* do not open in any part of the digestive tract of Chiton.

Of course there is the possibility that free spores may be taken in by some minute animal in which they germinate before passing back (perhaps by accidental swallowing) into another Chiton. However, no evidence is forthcoming on this point at present, although several Neosporidia have been already described from small marine animals.

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EXPLANATION OF THE PLATES.

Unless otherwise stated, the figures were drawn with a camera lucida from preparations stained with iron hæmatoxylin.

Lettering.

c., cyst; *ch.*, chitinous coat of spore; *d.*, daughter plasmodium; *g.*, gamete; *gr.*, chromatoid granule; *h.*, host-cell; *n.*, nucleus; *o.*, operculum; *s.*, sporoblast; *sp.*, spherule; *t.*, tail of spore.

Plate I.

Fig. 1. Section of a small Plasmodium of *Minchinia* with pseudopodia and several nuclei, some dividing. × 1000.

2. Another specimen showing Plasmotomy: *d.*, small daughter plasmodium partly covered by dividing parent form; *h.*, host-cells (phagocytes). × 2000.

Fig. 3. Portion of a section of an encysted parasite beginning to break up into gametes: *c.*, cyst with host-cells flattened against it; *g.*, amœboid gamete. Stained Ehrlich's hæmatoxylin. × 2000.

4. Portion of a cyst containing free and conjugating gametes. × 3000.

5. (*a*) Prozygote formed by fusion of the cytoplasm of two gametes. Stained Ehrlich's hæmatoxylin. (*b*) Zygote showing formation of syncaryon. (*c*) Zygote with syncaryon. All × 3000.

6. Zygote showing first division of the syncaryon. × 3000.

7. Later stage: second division nearly complete. × 3000.

PLATE II.

Fig. 8. Portion of a cyst showing two stages of division into the four sporoblasts: *s.*, free sporoblasts. × 3000.

9. Stages in early spore-formation from sections. × 3000. (*a*) Showing beginning of nuclear activity; (*b*) showing single parietal nucleus; (*c*) showing two such bodies and a portion of the membranous coat and tail cut through.

10. Young living spore from a cyst: the clearer space indicating position of nucleus. × 2000.

11. Slightly older spore also drawn from the living. × 2000.

12. Young spore with large nucleus giving off chromatic bodies into cytoplasm. × 3000.

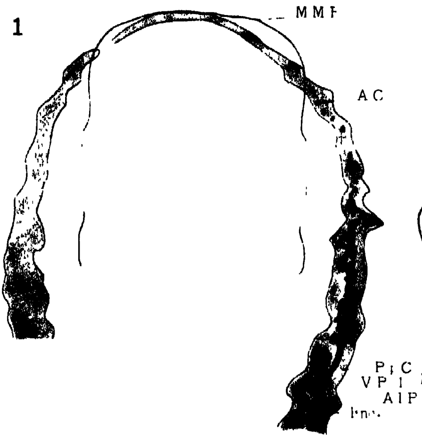
13. Optical section of a spore nearly full grown and with chitinous coat (*ch.*) almost complete. Membranous tails (*t.*) cut through spherule (*sp.*). × 3000.

14. Optical section of a free spore at stage between those represented by figs. 12 and 13, showing chromatic granules arranging themselves just inside membrane to form chitinous coat. Slightly flattened by cover-glass. × 2000.

15. Adult spore drawn from the living. × 1000.

16. Spore opened by means of pressure and reagents. × 1000.

1



Stage I. Perameles obesula (12 b)

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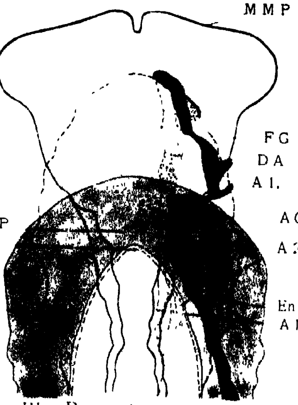
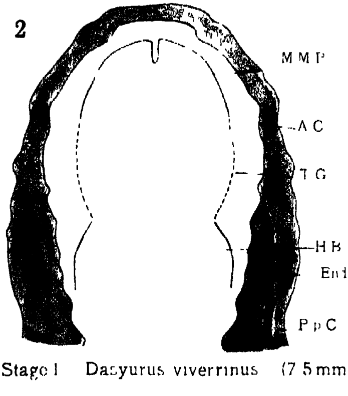


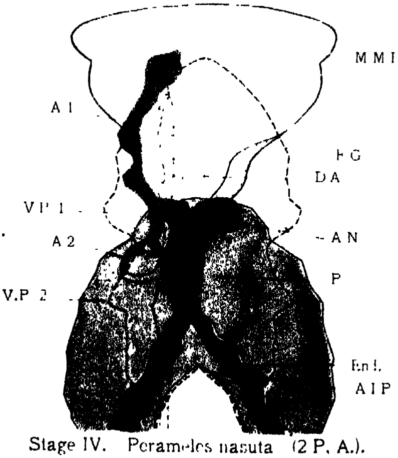
Stage III. Perameles nasuta (1S. A.).

2



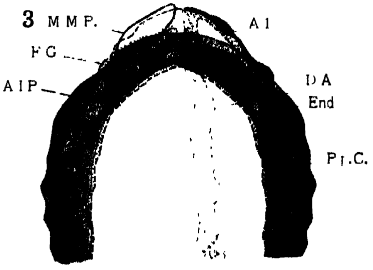
Stage I Dasyurus viverrinus (7.5 mm.).

5



Stage IV. Perameles nasuta (2 P. A.).

3

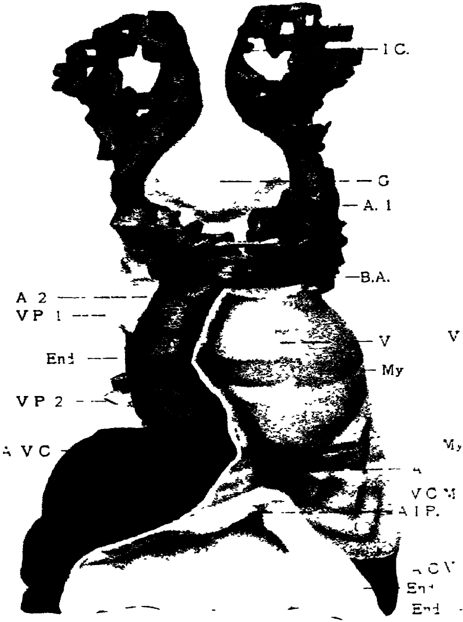


Stage II. Dasyurus viverrinus (8.5 mm. A.).

MENPES PRESS WATFORD

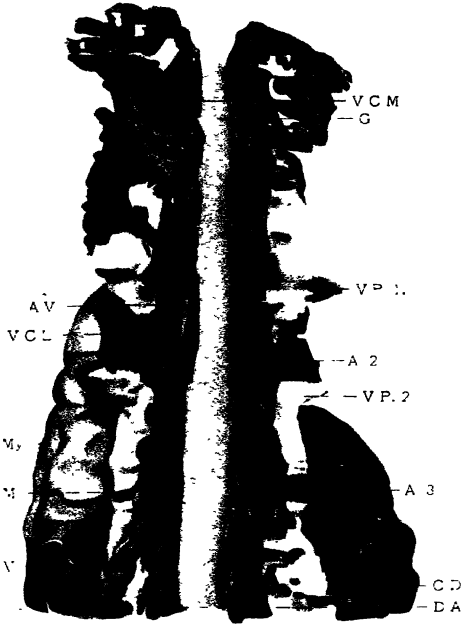
HEART OF MARSUPIAL EMBRYOS

P.Z.S. 1915. PARKER. Pl. II.



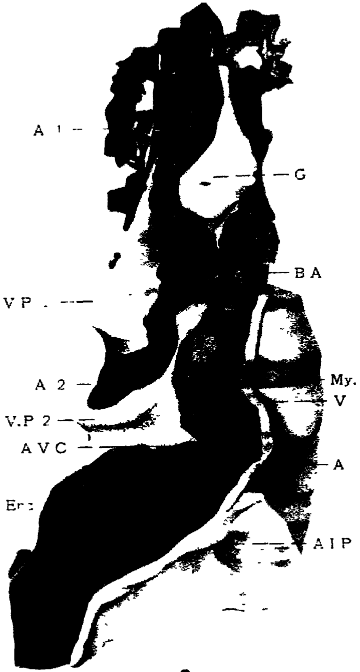
6

Model of Heart and Vessels of Head
Ventral View.



7

Dorsal View of Model.



8

Side View of Model.

F A STEELE, DEL

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MODELS OF EMBRYONIC MARSUPIAL HEART.

35. The Early Development of the Heart and Anterior Vessels in Marsupials, with Special Reference to *Perameles*.

By KATHARINE M. PARKER, B.Sc. (Lond.), Assistant in the Department of Zoology, University of London, University College *.

[Received May 25, 1915; Read June 8, 1915.]

(Plates I., II.† and Text-figures 1–25.)

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(*a*) Development of the Heart	486
(*b*) Development of the Cardinal Veins	493
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INTRODUCTION.

The following piece of work was undertaken at the suggestion of Professor J. P. Hill, for whose invaluable help in carrying it out I am deeply grateful. The embryos studied are all from his collection and text-figs. 1 and 6 were made from photographs taken by him.

I wish also to thank Miss E. A. Steele for her beautiful figures of the model (Stage V.) and Mr. F. C. Pittock for much help in making the model.

The material affords an excellent opportunity for the study of the mode of development of the pleuro-pericardial canals, the origin and differentiation of the endothelial heart-tubes, and the method of fusion of the lateral primordia of the heart, and it was in the hope of making some progress towards the solution of the interesting problems of early cardiac development that the work was undertaken.

The general arrangement of the pericardium, heart, and aorta in the early stages (viz. Stages I. to IV. inclusive) can be accurately determined by graphic reconstruction. Figures 1 to 5 (Pl. I.) were all obtained by this method, and are intended to give some idea of the relations of the pericardium and heart to the gut and the brain-plate in successive stages.

In the next stage (Stage V.) the curvature of the heart makes it impossible to represent the relations of the parts accurately in two dimensions. A wax-plate reconstruction was therefore made (see Pl. II.), and as all the vessels of the head which were recognisable as such were included in the model, a certain amount of light was shed on the development and early relations of the cardinal veins and aortic arches. The following account therefore deals not only with the development of the heart, but also with certain facts relative to the early development of the vessels of the head.

---

* Communicated by Prof. J. P. HILL, D.Sc., F.R.S., F.Z.S.

† For explanation of the Plates see p. 499.

DESCRIPTION OF STAGES.

STAGE I. *Perameles obesula* (1 Z).
Dasyurus viverrinus (7·5 mm. vesicle).

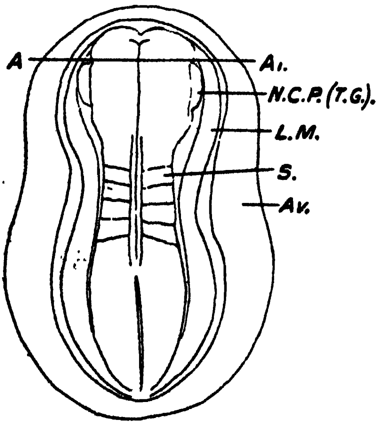
The material for this stage consists of four embryos of *Perameles obesula*, one cut longitudinally and three transversely, and several of *D. viverrinus*.

(a) *Perameles obesula* (1 Z).

* Total length of embryo A in curved condition = 6·08 mm.

In this stage there is a flat brain-plate with an extensive neural crest proliferation in the cranial region (text-fig. 1, *N.C.P.* (*T.G.*)).

Text-figure 1.



Perameles obesula (1 Z). Dorsal view of embryo A.

Av. Area vasculosa. *L.M.* Lateral mesoderm. *N.C.P.* (*T.G.*). Neural crest proliferation (primordium of trigeminal ganglion). *S.* Somite. *A*, *A*₁. Level of section represented in text-fig. 2.

There are four distinct somites (*S.*): behind the fourth is a somitic thickening with an indistinct posterior limit, and in front of the first, another imperfectly defined mass, representing presumably a transitory first somite.

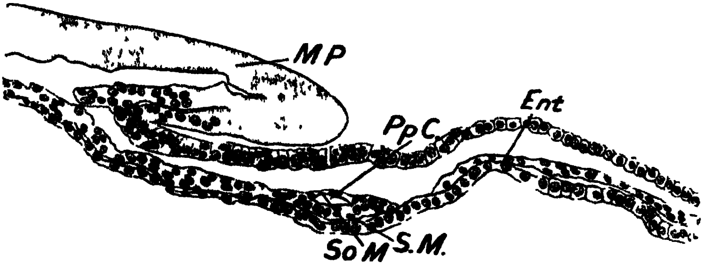
---

* All measurements of embryos and certain descriptive details are taken from Professor Hill's original notes and photographs of the material.

Laterally to the somitic mesoderm and the medullary plate is a zone appearing clear in surface view, in which the mesoderm forms a thin sheet. Outside this again is an opaque zone of lateral mesoderm (*L.M.*), completely surrounding the embryo. This is bounded peripherally by a clear zone which separates it from the area vasculosa (*A v.*). The entoderm forms a thin continuous layer, while a small incipient head-fold definitely marks the anterior margin of the brain-plate and involves also the protochordal plate lying in the middle line immediately below it.

In the lateral mesoderm on each side a horizontal cleft has appeared, separating the mesoderm into a dorsal somatic and a ventral splanchnic layer. These clefts, commencing on both sides of the embryo and extending forwards, constitute the pleuro-pericardial canals, the form of which can readily be seen in Pl. I. fig. 1 (*P.p.C.*) The canals form a horseshoe the median anterior portion of which lies underneath the anterior margin of the brain-plate (*M.M.P.*), while the lateral limbs extend back into the somitic region. In the anterior region, the dorsi-ventral extent of the pleuro-pericardial canal is very small (text-fig. 2, *P.p.C.*), and in fact the continuity of the canal is actually interrupted on the right side of the embryo (Pl. I. fig. 1).

Text-figure 2.



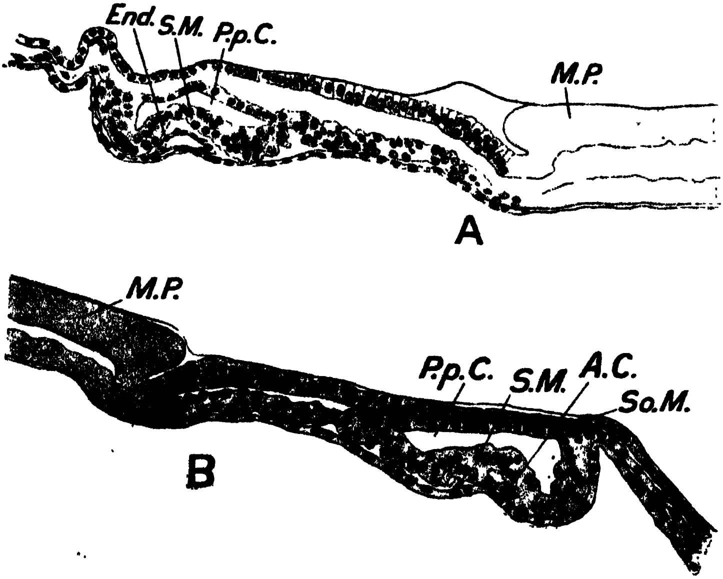
Perameles obesula (1 Z, B). Transverse section in plane A, A_1. (See text-fig. 1.)

Ent. Entoderm. *M.P.* Medullary plate. *P.p.C.* Pleuro-pericardial canal. *S.M.* Splanchnic mesoderm. *So.M.* Somatic mesoderm.

The cleft increases markedly in size in the region of the trigeminal neural crest proliferation (text-fig. 1, *N.C.P.* (*T.G.*)) and attains its greatest size in the hind-brain region (text-fig. 3 A & B). Behind this it becomes reduced in size until, opposite the posterior somites, the cœlomic cavity is represented by irregular clefts in the lateral mesoderm.

The pleuro-pericardial canals throughout their extent have a thin somatic and a slightly thicker splanchnic wall (see text-figs. 2, 3 A & B, *So.M.*, *S.M.*), which in the anterior region is in close contact with the entoderm (text-fig. 2). In the region of the maximum size and development of the pleuro-pericardial canals (Pl. I. fig. 1) the endothelial primordia of the heart are differentiating (text-fig. 3, *End.*) between the entoderm and the splanchnic mesoderm, which therefore projects as a prominent fold into the pleuro-pericardial canal.

Text-figure 3.



Perameles obesula (1 Z, B).

A. Transverse section in region of greatest width of pleuro-pericardial canals, with endothelial tubes developed. B. Transverse section showing origin of angioblast cells from the splanchnic mesoderm.

A.C. Angioblast cell. *End.* Endothelium. *M.P.* Medullary plate. *P.p.C.* Pleuro-pericardial canal. *S.M.* Splanchnic mesoderm. *So.M.* Somatic mesoderm.

The endothelial heart primordia are best developed in their posterior portions, where they are actually tubular in some embryos of this stage (see text-fig. 3 A). Anterior to the tubular portion, the primordia are represented by solid cords of angioblast cells, isolated examples of which are found scattered along the length of the pleuro-pericardial canals in the positions indicated in Pl. I. fig. 1 (*A.C.*). It may be concluded from this that the endothelial tubes differentiate postero-anteriorly, and that their increase in length is brought about not by direct forward growth of the first formed parts of the tubes, but by the progressive differentiation of angioblast cells in the cephalic portions of the pleuro-pericardial canals.

The evidence of this stage does not justify any definite statement with regard to the origin of the endothelium of the heart. From text-fig. 3 B it will be seen that the splanchnic mesoderm (*S.M.*) shows distinct traces of proliferative activity; its ventral, indented margin has an irregular outline and there are indications of loosening of the cells. On the other hand, there is no definite evidence of entodermal proliferation, though in an earlier stage, which will form the subject of a separate paper, the appearances by no means exclude the possibility of the entodermal origin of the endothelium, whilst there is clear evidence of proliferative activity on the part of the entoderm of the area vasculosa.

(b) *Dasyurus viverrinus* (7·5 mm. vesicle).

The material on which the following description is based consists of two embryos, one cut transversely, the other longitudinally.

Greatest length of each embryo = 7 mm.

In this stage there is a flat brain-plate, the anterior margin of which is marked in the middle line by a thickened terminal ridge (text-fig. 4, *T.R.*). There is a well developed neural crest proliferation, the anterior portion representing the primordium of the trigeminal ganglion, and the posterior that of the facial, glosso-pharyngeal and vagus ganglia. No somites are yet differentiated.

The outline of the anterior end of the brain-plate and the pleuro-pericardial canals and endothelial heart-tubes are shown in Pl. I. fig. 2. From this it will be seen that the pleuro-pericardial canals (*P.p.C.*) extend continuously round the head-end of the embryo and lie anterior to the anterior margin of the brain-plate (*M.M.P.*).

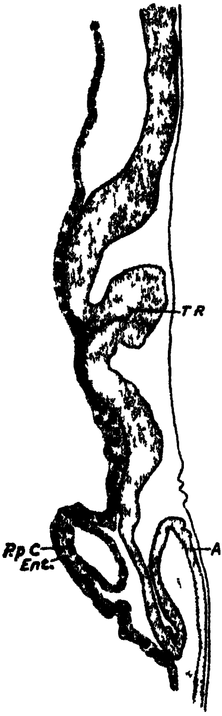
The pleuro-pericardial canals attain their greatest size in the hind-brain region (*H.B.*) at this stage, and here also the primordia of the heart are well established in the form of endothelial tubes lying between the entoderm and the thickened splanchnic mesoderm. The endothelial tubes terminate anteriorly at the level of the posterior limit of the trigeminal primordium. In front of this, however, there are scattered angioblast cells and strands of cells extending forwards as indicated in Pl. I. fig. 2. In the condition of the heart primordia the *Dasyurus* embryos are in advance of those of *Perameles* described above, for the endothelium is definitely tubular throughout a great portion of its extent and the myocardial fold is consequently well developed.

From the longitudinal section (text-fig. 4) it will be seen that the antero-median portion of the pleuro-pericardial canal lies some distance in front of the anterior margin of the brain-plate (*T.R.*).

In Stage I., then, we have a horseshoe-shaped pleuro-pericardial cavity extending round the embryo and with the lateral limbs prolonged into the somitic region. The endothelial primordia of the heart are represented by more or less continuous tubes, solid cords, and scattered angioblast cells differentiating in the postero-anterior direction and lying between the entoderm and the splanchnic mesoderm.

The endothelial heart-tubes are the only vessels yet established.

Text-figure 4.



Dasyurus viverrinus (7·5 mm. vesicle). Longitudinal section, median through the anterior margin of the brain-plate.

Amn. Head-fold of amnion. *Ent.* Entoderm. *P.p.C.* Pleuro-pericardial canal. *T.R.* Terminal ridge.

Stage II. *Dasyurus viverrinus* (8·5 mm.).

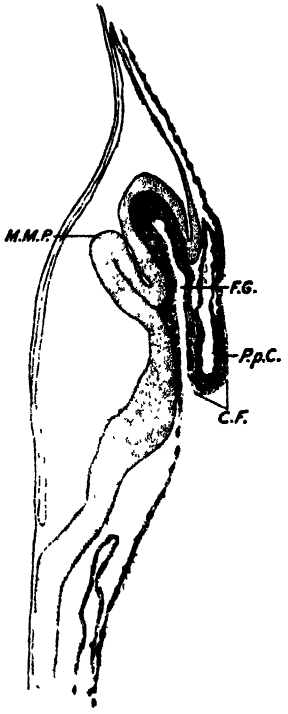
The material for this stage consists of one embryo (A) of *Dasyurus viverrinus* cut transversely and one (A*a*) cut longitudinally. A graphic reconstruction of the gut and pericardium together with the endothelial heart-tube and aorta of the left side of embryo A will be found in Pl. I. fig. 3.

Total length of embryo A, 8·5 mm.

This embryo possesses a flat brain-plate with well marked optic grooves; somites are not as yet distinctly differentiated.

The position of the anterior margin of the brain-plate is indicated in fig. 3 (*M.M.P.*) as well as the outline of the gut (*F.G.*). On comparison with fig. 2, it is clear that the progress of the head-fold has brought about considerable alteration in the relations of the gut, brain, and pericardium (see Pl. I. fig. 3 and text-fig. 5). In embryo A (fig. 3), which is slightly in advance of embryo A*a* (text-fig. 5), the anterior margin of the brain-plate now marks the actual anterior limit of the embryo, while at the same time the crescent-shaped fore-gut (*F.G.*) has developed. Its anterior limit lies immediately behind the anterior margin of the brain-plate, while closely applied to its posterior and lateral

Text-figure 5.



Dasyurus viverrinus (8·5 mm.). Longitudinal section of embryo A*a*, median through anterior end.

C.F. Cardiac fold. *F.G.* Fore-gut. *M.M.P.* Margin of medullary plate. *P.p.C.* Pleuro-pericardial canal.

margins lies the continuous pericardial cavity which shows a marked increase in size as compared with the previous stage. (Compare Pl. I. figs. 2 & 3, *P.p.C.*) This increase is greater in the median anterior limb of the pericardium than in its lateral portions. (Compare text-figs. 4 & 5.)

The differentiation of the endothelial primordia of the heart has progressed considerably and they now extend as actual tubes even to the middle line of the pericardium. This fact is somewhat remarkable, as such a condition, in which the lateral heart-tubes are actually in contact at their extreme cephalic apices and diverge widely and abruptly from this point of contact, is not found in any other stage.

Some distance behind its cephalic extremity, the lateral heart-tube gives rise to the first aortic arch (fig. 3, *A* 1), which follows the antero-lateral margin of the gut almost to the middle line and there becomes continuous with the corresponding dorsal aorta, the two aortæ being completely established in this stage.

It will be unnecessary to go into further details of the structure of this embryo, as the sectional appearances found in it are exemplified yet more clearly in the *Perameles* embryo to be described next. It is, however, an important stage with regard to the processes of growth and folding which bring about the relations of the brain, gut, and pericardium which are found in subsequent stages.

STAGE III. *Perameles nasuta* (1 S).

The material in this stage consists of two flat embryos with widely open brain-plates and lateral heart-tubes. Embryo A has eleven somites, the first being small and indistinctly limited; embryo B has nine, the most anterior being indistinct here also. The following description* is based mainly on embryo A, which was cut transversely.

Total length of embryo A after partial flattening under cover-glass, from the anterior margin of the brain-plate to the hinder extremity of the primitive streak: 7·5 mm.

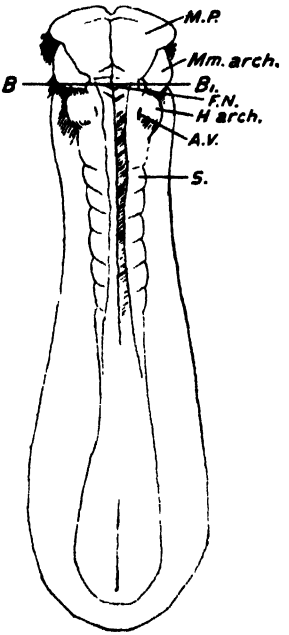
Vascular area, 8·96 × 5·8 mm. in diameter.

Text-fig. 6 represents a dorsal view of embryo A, while the outlines of the gut and pericardium and the endothelial heart-tube and aorta of the left side are given on Pl. I. fig. 4. From these figures it will be seen that the stage shows a considerable advance in general development on the preceding. The head-fold has progressed back as far as the region of the auditory pit. The brain, though flat and widely open in the fore- and mid-brain regions, is deeply grooved in the hind-brain region. Lying lateral to the brain-plate are two pairs of mesodermal masses, one the maxillo-mandibular process, the other the hyoid arch. Between these two arches is the first visceral pouch, and behind the hyoid arch the second visceral pouch is already developed.

Shortly behind this, the paraxial mesoderm is differentiated into somites.

The maxillo-mandibular process (text-fig. 6, *Mm. arch.*) forms a dense mass of mesoderm not distinctly marked out into maxillary and mandibular portions. It lies laterally to the gut on the outer side of the lateral and dorso- and ventro-lateral walls of the gut, and extends antero-posteriorly from almost the anterior end of the gut back to the first visceral pouch, which is situated level with the anterior intestinal portal. The entoderm of the first visceral pouch reaches the ectoderm, but the closing membrane is not perforated.

Text-figure 6.



Perameles nasuta. Dorsal view of embryo A.

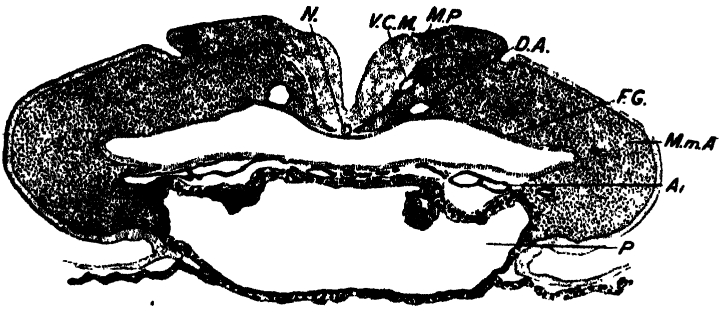
B, B_1 indicates the level of the section represented in text-fig. 7.

A.v. Auditory vesicle. ***F.N.*** Facial neuromere. ***H.arch.*** Hyoid arch. ***Mm. arch.*** Maxillo-mandibular arch. ***M.P.*** Medullary plate. ***S.*** Somite.

The hyoid arch is a mass of mesoderm only slightly smaller in surface view than the maxillo-mandibular arch, but situated entirely dorsal to the gut. Behind it is the second visceral pouch, which is small and does not reach the ectoderm (Pl. I. fig. 4, *V.P.* 2).

The form of the pericardium and its relations to the gut, as well as the topography of the endothelial heart-tubes and the aortæ and aortic arches, will be understood best by reference to fig. 4 and text-fig. 12. From fig. 4 it will be seen that the pericardium (*P.*) has increased markedly in size. As in the previous stage, its inner wall is closely applied to the entoderm of the crescentic or U-shaped anterior intestinal portion (*A.I.P.*) (*cf.* text-fig. 12). The antero-median portion of the pericardium is somewhat rectangular in transverse section (text-fig. 7); its dorsal wall is slightly thicker than its ventral, and between the former and the floor of the gut lie the endothelial heart-tubes (text-fig. 8) and the first aortic arches (text-fig. 7).

Text-figure 7.



Perameles nasuta (1 S, A.). Transverse section through median pericardium and first aortic arch.

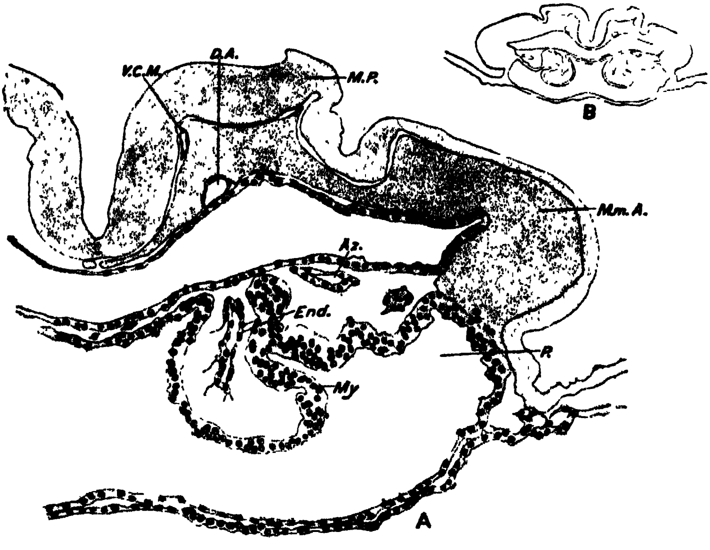
A_1. First aortic arch. *D.A.* Dorsal aorta. *F.G.* Fore-gut. *M.P.* Medullary plate. *M.m.A.* Maxillo-mandibular arch. *N.* Notochord. *P.* Pericardium. *V.C.M.* Vena capitis medialis.

In the antero-median limb of the pericardium, the endothelial heart-tubes, enclosed in a fold of splanchnic mesoderm, lie separate from each other below the closed gut (Pl. I. fig. 4 and text-fig. 8), while at the level of the anterior intestinal portal they diverge in the manner indicated in fig. 4 and lie on either side of the open gut in the dorso-medial wall of the pericardium (text-fig. 9). In their posterior portions the heart primordia lie on the ventral side of the pericardium.

The endothelial heart-tubes throughout their length are almost completely enclosed by the layer of splanchnic mesoderm constituting the primordium of the myocardium. In the posterior region of the heart the myocardial layer is closely applied to the outside of the endothelial tube (text-fig. 10), but in the greater part of its extent there is a considerable space between the two layers of the heart primordium (text-fig. 9).

From the cephalic extremity of each endothelial tube, there arise two vessels, one of which runs forwards and outwards towards the lateral margin of the gut and then parallel with this margin (Pl. I. fig. 4, A_1). It loops round the anterior limit of the gut, joins the dorsal aorta, and thus constitutes the first or mandibular aortic arch. It is impossible here to fix any exact limit between the endothelial heart-tube and the aortic arch. Text-figs. 7 and 8 represent typical sections through each. The transition from the heart primordium to the aortic arch is indicated by the gradual reduction in the dorsi-ventral extent of the space surrounding the endothelial tube and the rotation of the vessel, so that its greatest diameter comes to lie parallel with the floor of the gut. (Compare text-figs. 8 and 7.) Outside the limits of the pericardium the aortic arch runs in the mesoderm of the maxillo-mandibular process (text-fig. 7). It is connected with the dorsal aorta by one main loop and by several smaller vessels which were omitted from fig. 4 for the sake of clearness.

Text-figure 8.



Perameles nasuta (1 S, A.).

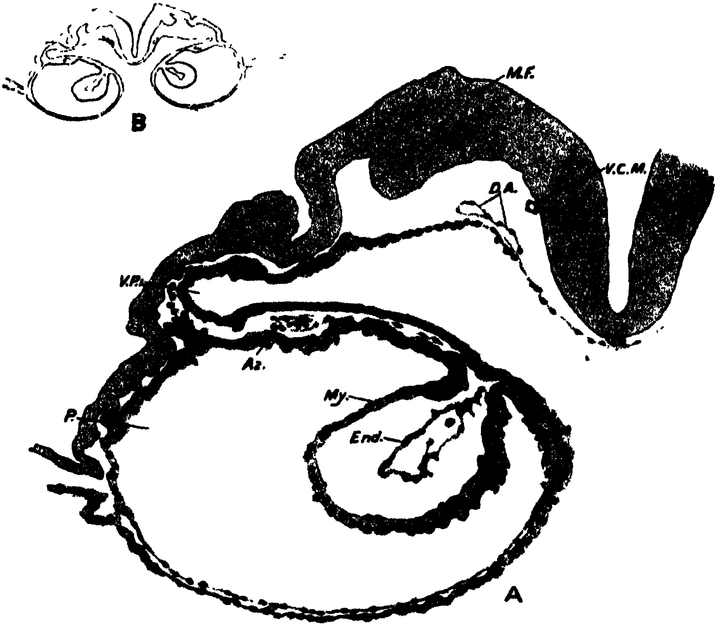
A. Transverse section through heart primordia and second aortic arch.
B. Complete outline of same section.

A_2. Second aortic arch. *D.A.* Dorsal aorta. *End.* Endothelium of heart. *M.m.A.* Maxillo-mandibular arch. *M.P.* Medullary plate. *My.* Myocardium. *P.* Pericardium. *V.C.M.* Vena capitis medialis.

The second vessel, which arises from the anterior end of the heart, is small and runs backwards and outwards, lateral to and almost parallel with the heart-tube, and has precisely the same relations to the gut and mesoderm.

Comparison with the succeeding stages shows that this represents the ventral portion of the future second aortic arch (Pls. I., II., figs. 4 & 8, *A* 2), while a small vessel arising from the dorsal aorta and running outwards on the dorsal wall of the gut ventral to the auditory vesicle, corresponds with the dorsal portion of the completed arch in later stages.

Text-figure 9.



Perameles nasuta (1 S, A.).

A. Transverse section in region of lateral heart primordia and open gut.
B. Complete outline of same section.

A_2. Second aortic arch. *D.A.* Dorsal aorta. *End.* Endothelium of heart. *M.F.* Medullary fold. *My.* Myocardial layer. *P.* Pericardium. *V.C.M.* Vena capitis medialis. *V.P.*1. First visceral pouch.

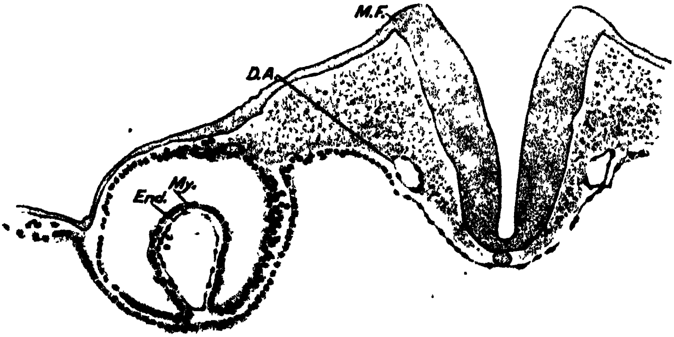
In the median space between the anterior ends of the endothelial heart-tubes are a number of scattered angioblast cells lying between the splanchnic mesoderm and the entoderm (Pl. I. fig. 4 and text-fig. 7). These cells possibly represent the primordia of the capillaries found in the corresponding position in the next stage. They afford an instance of the origin of angioblast cells from the splanchnic mesoderm after the establishment of the definitive endothelial heart-tubes.

Posterior to the region represented in fig. 4, the heart-tubes gradually curve outwards and pass imperceptibly into vitelline veins.

The dorsal aorta is paired and runs back continuously, the two vessels keeping approximately the same distance from the middle line (Pl. 1. fig. 4, *D.A.*).

Immediately dorsal to the dorsal aorta on each side there is situated a series of apparently isolated sections of a minute blood-vessel (text-fig. 7, *V.C.M.*). These capillaries lie close against the medullary tube, medially to the neural crest proliferation in the region of the trigeminal ganglionic primordium. From the position of this vessel relative to the dorsal aorta and nerves, it is evidently the vena capitis medialis of Grosser (5). A brief summary of some of the literature on the subject of the venæ capitis medialis and lateralis and their relations to the anterior cardinals will be found below, together with a review of the facts of development of these veins in *Perameles*.

Text-figure 10.



Perameles nasuta (1 S, A.). Transverse section through posterior portion of lateral heart primordia.

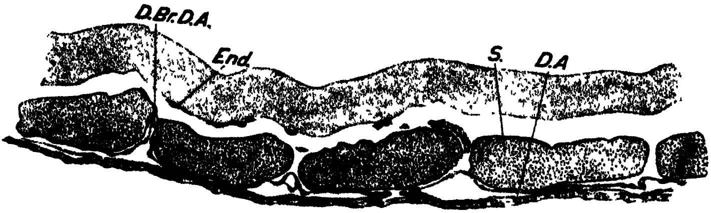
D.A. Dorsal aorta. *End.* Endothelium of heart. *M.F.* Medullary fold. *My.* Myocardial layer.

Although it is not within the scope of this paper to deal in any detail with the posterior vessels, it may be noted here that in this stage, in the region of the posterior somites, there occur intersegmental offshoots from the dorsal aortæ. These intersegmental offshoots are shown very clearly in the longitudinal series (text-fig. 11). It will be seen from the figure that between each two successive somites (*S.*) there is a small dorsal offshoot from the aorta. Dorsal to the somites there are a few scattered endothelial cells (*End.*). The longitudinal vessel connecting the offshoots is not continuous, but portions of it are present in the next section.

At the level of the second somite there occurs a pair of small vessels lying in the somatopleure immediately dorsal to the heart-tubes. Each consists of a single vessel with a few minute branches and is blind at both ends and not connected as yet with any other capillaries. From these vessels the Cuvierian ducts are later developed.

In this stage we have, therefore, lateral heart-tubes which, while they approach one another anteriorly, are widely separate in the posterior region. Paired dorsal aortæ and the first pair of aortic arches are developed, whilst traces of the second arch are also present. This stage accordingly agrees in its general features with the $8\frac{1}{2}$ days rabbit described by Bremer (1). In addition to the heart and arterial vessels there are also present in the head the first traces of the venous system in the form of disconnected portions of the vena capitis medialis and the primordia of the Cuvierian ducts.

Text-figure 11.



Perameles nasuta (1 S, B.). Longitudinal section through somites showing dorsal offshoots from the dorsal aorta.

D.A. Dorsal aorta. *D.Br.D.A.* Dorsal branch of same. *End.* Endothelium of longitudinal vessel. *S.* Somite.

Stage IV. *Perameles nasuta* (2 P).

The material consists of four embryos, A and C cut transversely, B and D longitudinally.

Each of the four embryos has fifteen or sixteen somites. The neural tube is still unclosed throughout its length, but the folds are closely approximated in the hind-brain region. The mid- and fore-brain segments are widely open as in Stage III., but the primary cranial flexure has occurred so that the fore-brain is bent forwards and downwards (see text-fig. 15).

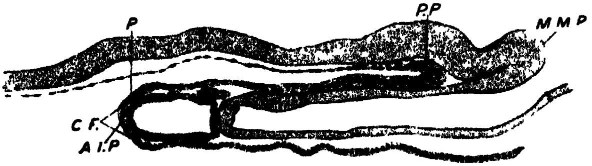
The relations of the gut, pericardium, and heart are indicated in Pl. I. fig. 5. It is well to note at this point that the outline of the brain-plate as indicated in figure 5 is not strictly comparable with the corresponding line in fig. 4 (compare text-figs. 12 and 15). The fact that the primary cranial flexure has occurred, renders it impossible to plot the morphological anterior end of the brain in the same plane reconstruction with the hind-brain, gut, etc. The difference in the relations of the brain to the pericardium in the two stages may, however, be judged by the position of the auditory neuromere (*A.N.*), which lies at the posterior margin of the pericardium in

Stage III. and at the anterior margin thereof in the present stage.

The first and second visceral pouches are now well marked (fig. 5, *V.P.* 1 & 2), while the relations of the maxillo-mandibular process and hyoid arch show little advance on the preceding stage.

The antero-median portion of the pericardium has increased very considerably in the antero-posterior direction. Furthermore, it may be noted that as the portion of the gut lying anterior to the first visceral pouch has remained the same length (compare figs. 4 & 5) and the anterior margin of the pericardium is now situated in the same plane with the first visceral pouch, the pericardium must have moved backwards as a whole.

Text-figure 12.



Perameles nasuta (1 S, B). Longitudinal section, median through the anterior end.

A.I.P. Anterior intestinal portal. *C.F.* Cardiac fold. *M.M.P.* Margin of medullary plate. *P.* Pericardium. *P.P.* Protochordal plate.

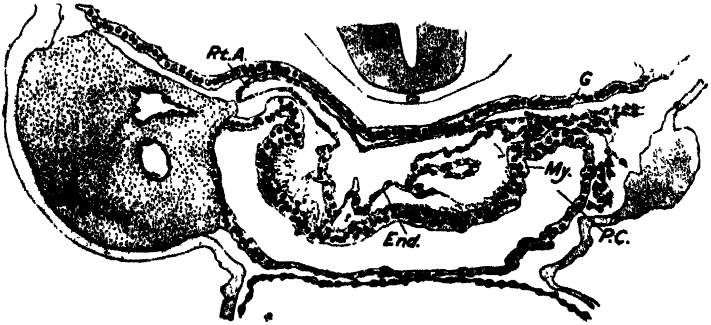
The form of the endothelial primordia of the heart is shown in fig. 5. They have fused at their cephalic extremity, the fused portion extending through some eighteen sections and representing the most closely approximating portions of the endothelial tubes in Stage III. (Pl. I. fig. 4). From it is derived the bulbus (conus) arteriosus of the next stage (Pl. II. fig. 8, *B.A.*). Posterior to this fused portion, the endothelial tubes lie close together but unfused for a considerable portion of their length (Pl. I. fig. 5 and text-fig. 14), and then diverge widely and pass into vitelline veins. The endothelial tubes throughout their length are enclosed by the myocardial wall, which shows characteristic thickening and prolongations of its cells throughout the greater part of the length of the heart (text-fig. 14, *My.*).

The myocardium of the right and left sides is united from the cephalic extremity of the heart primordium to the point of divergence of the right and left endothelial tubes, but the line of fusion is not marked by any groove. In the posterior region where the endothelial tubes separate from each other, each is surrounded by its own myocardial layer, so that for a short distance in front of the anterior intestinal portal, the two heart-tubes lie below the closed gut, each surrounded by an independent fold of splanchnic mesoderm. The primordia of the heart are prolonged into the lateral gut-folds and pass gradually into vitelline veins.

The heart as a whole is somewhat asymmetrical (see fig. 5), being curved over to the right side of the embryo.

The aortic arches, two of which are developed, arise from the median bulbus arteriosus. The endothelial heart-tube bifurcates in front, and each half runs forwards and slightly outwards as a relatively wide vessel situated between the two layers of the splanchnopleure. These vessels, which constitute the first aortic arches, run forwards and outwards in a course similar to that of the same vessels in the next stage (compare figs. 5 and 6). Anteriorly they loop round the gut to join the dorsal aortæ. From the anterior convexity of this first aortic arch are given off capillaries which form a network surrounding the primary optic vesicles. From the lateral margin of the fused tip of the heart is given off on each side a small vessel which runs outwards and backwards, loops round the gut, and constitutes a continuous though slender second aortic arch.

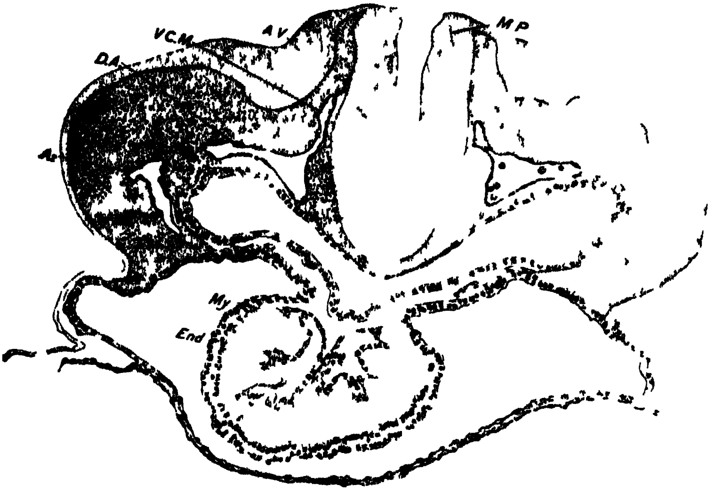
Text-figure 13.



Perameles nasuta (2 P, A). Transverse section through bulbus arteriosus.
End. Endothelium. *G.* Gut. *My.* Myocardium. *P.C.* Pericardial cavity.
Rt.A. Root of aortic arch.

The vena capitis medialis, which was just recognisable in the preceding stage, is now considerably further developed. It is represented by an irregular and not perfectly continuous series of capillaries, situated dorsal to the aorta on either side of the medullary tube, medial to the cranial ganglia. These capillaries are connected by very fine sprouts with the dorsal aortæ (text-fig. 14, *V.C.M.*); ventro-lateral to the auditory vesicle and lateral to the nerve-roots, there is another line of scattered capillaries connected with the vena capitis medialis. These are the first traces of the vena capitis lateralis. Portions of the vena capitis medialis can be traced in the region of the lateral heart-tubes as far back as the Cuvierian ducts (*i. e.*, the region of the third somite). Behind this again there are, as in Stage III, intersegmental offshoots from the dorsal aorta, but as yet no continuous vessel in this region

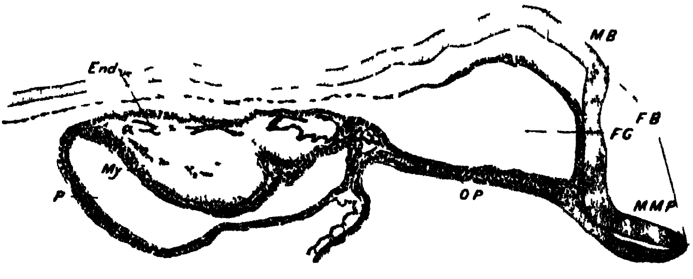
Text-figure 14.



Perameles nasuta (2 P, A). Transverse section through ventricular region of the heart.

A_2 Second aortic arch. *A V* Auditory vesicle. *D A* Dorsal aorta. *End* Endothelium. *M P* Medullary plate. *My* Myocardium. *V C M* Vena capitis medialis.

Text-figure 15.



Perameles nasuta (2 P, B).

Longitudinal section, median through the anterior end of the embryo.

End Endothelium. *F B* Fore-brain. *F G* Fore-gut. *M B* Mid brain. *M M P* Margin of medullary plate. *My* Myocardium. *O P* Oral plate. *P.* Pericardium.

In this stage the Cuvierian ducts are recognisable lying in the somatopleure opposite the third somite and immediately dorsal to the heart-tube. The main trunk of each ends blindly anteriorly and posteriorly and is of considerable size, causing a bulging of the mesoderm of the somatopleure, which is thus brought into contact with the mesoderm surrounding the heart-tube. As yet, however, neither of the Cuvierian ducts opens into the heart-tube. From the medial side of each Cuvierian duct a few small capillaries are given off. They run towards the middle line and represent that portion of the anterior cardinal vein which at a later stage connects the venæ capitis medialis and lateralis with the Cuvierian duct. (Compare Pl. II. fig. 7, *A.C.V.*)

Stage IV., therefore, possesses a heart in which the endothelial tubes have fused anteriorly and curvature has already commenced. Two complete aortic arches, an incomplete vena capitis medialis, traces of a vena capitis lateralis, and Cuvierian ducts are present.

STAGE V. *Perameles obesula* (10. viii. 03).
Macropus sp.

The material for this stage consists of five similar embryos of *P. obesula*, three cut transversely and two longitudinally, and one embryo of *Onychogale frenata* (? *Macropus* sp.) cut transversely. In several respects, *e. g.* curvature of the heart, the *Onychogale* embryo represents a slightly earlier stage than *Perameles obesula* (10. viii. 03). For purposes of description, however, it will be convenient to deal first with the *Perameles* embryos, as a wax-plate reconstruction was made of the heart and anterior vessels of embryo A (Pl. II. figs. 6–8).

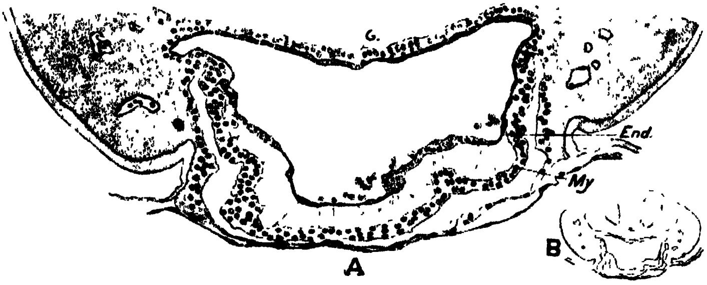
As regards general development, *Perameles obesula* (10. viii. 03) shows only a slight advance on *P. nasuta* (1 S) Stage III. The brain has practically not changed; the gut is in the same condition except that the first visceral pouch is more extensive and closure of the fore-gut has progressed back to slightly behind the auditory vesicle.

In the vascular system, however, we find a most marked advance, the heart having assumed a definite form with ventricular and auricular divisions recognisable. Figs. 6 to 8 illustrate the model of the heart and anterior vessels in this stage. The gut, included to form a building base, is coloured white, heart endothelium and arteries red, veins and most of the capillaries blue, myocardium yellow. The myocardium is left intact on the left half of the model from the roots of the aortic arches back to the level of the anterior end of the Cuvierian duct, but has been omitted on the right side so that the whole of the endothelial tube is here exposed to view. The capillaries surrounding the gut are also left intact on the left side of the model, but on the right have been omitted in order that the aortic arches might be seen more clearly. Study of the actual sections shows that the capillaries of the right side closely resemble those of the left.

The first and second visceral pouches are seen in the model as lateral projections from the gut (figs. 6–8, *V.P.* 1 & 2). The heart, which is median and ventral anteriorly, still consists of separate lateral primordia posteriorly, the two halves diverging in the lateral lips of the anterior intestinal portal (fig. 6, *A.I.P.*). By the great enlargement of the heart itself, the pericardial cœlom has become relatively considerably reduced, and now simply forms a space surrounding the heart ventrally and ventro-laterally (text-fig. 18). The median pericardium extends from the cephalic extremity of the heart to the anterior intestinal portal.

At their cranial ends the endothelial tubes (exposed in the model by the omission of the myocardium) unite to form a broad conical portion, the bulbus (conus) arteriosus. The first and second aortic arches (*A.* 1 & 2) are given off from the dorsal side of the bulbus (fig. 8, *B.A.*, *A.* 1 &c.). In this region, the myocardium simply forms a continuous layer covering the endothelium, but separated from it by a space (text-fig. 16). The bulbus is the only portion of the heart in which the endothelial tubes have actually fused. Behind it, the tubes are in contact as far back as the anterior intestinal portal, but the wall between them is everywhere complete. The myocardium of the two sides has fused throughout the region of the closed gut and there is no ventral mesentery (text-figs. 16–18). There is, however, a very well marked groove on the ventral aspect of the myocardium, which marks the line of junction of the right and left halves. At the opening of the gut the right and left heart primordia separate completely.

Text-figure 16.



Perameles obesula (10.viii.03).

A. Transverse section through bulbus arteriosus.
B. Complete outline of same section.

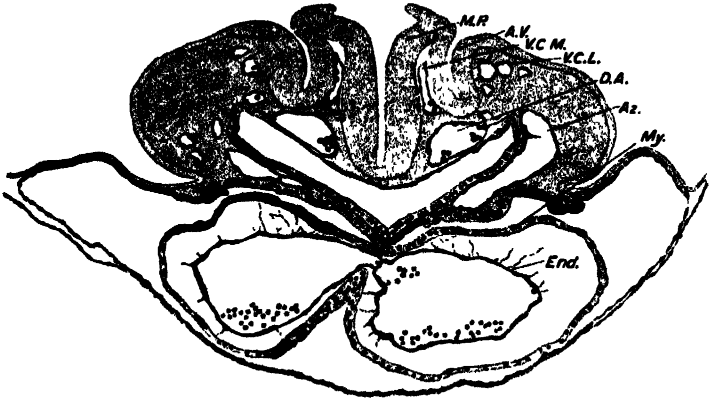
End. Endothelium of bulbus arteriosus. *G.* Gut. *My.* Myocardium.

From the ventral view of the model (Pl. II. fig. 6) it is obvious that already the heart has begun to bend between the two points (*a*) the roots of the aortic arches and (*b*) the opening of the fore-gut

The curvature, however, does not affect both sides equally, and a marked asymmetry results. The anterior ventricular portions of the heart-tubes are already being pushed backwards so as to lie ventral to the auricular portions. It is clear that by continuation of this curvature with accompanying fusion of the two halves, the typical embryonic relations of auricle and ventricle will ultimately be achieved.

In the ventricular region of the heart, the right and left endothelial tubes are approximately equal in size, but where there is an inequality the right is the larger (text-fig. 17, *End.*)

Text-figure 17.



Perameles obesula (10.viii.08). Transverse section through the ventricular region of the heart.

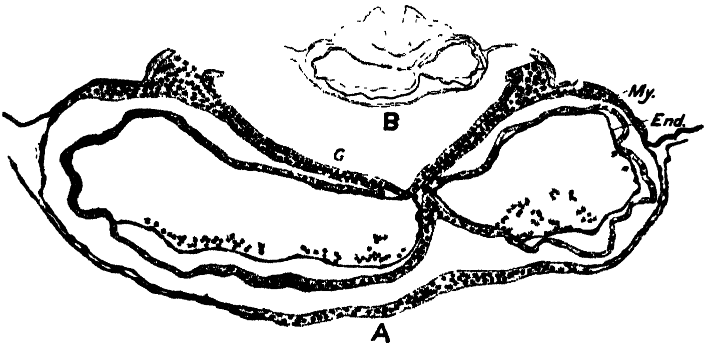
A_2. Second aortic arch. *A.V.* Auditory vesicle. *D.A.* Dorsal aorta. *End.* Endothelium. *M.P.* Medullary plate. *My.* Myocardium. *V.C.L.* Vena capitis lateralis. *V.C.M.* Vena capitis medialis.

In addition to the curvature which is bringing the ventricular region into position ventral to the auricular region, there is a certain amount of curvature in the horizontal plane of the embryo.

In the right half of the heart, a definite constriction of the endothelial tube marks the limit between the ventricular and auricular portions. On the left side there is no such constriction. Posterior to this constriction the right endothelial tube widens out suddenly, reaching about three times its width in the constricted region. The left endothelial tube in this region widens only very slightly. The right and left heart primordia furthermore show considerable asymmetry as regards curvature, for while the portion of the left tube lying lateral to the open fore-gut is practically straight, the right tube in this region shows well marked curvature. (See Pl. II. fig. 6.) Correlated with this difference in the size and curvature of the endothelial tubes, the opening of the fore-gut is also asymmetrical (fig. 6, *A.I.P.*). At the anterior intestinal portal, the right and left primordia of the heart separate, and both tubes become reduced in size, the right, however, more markedly than the left. The endothelial heart-tubes pass imperceptibly into vitelline veins.

A further distinction between the ventricular and auricular portions of the heart lies in the fact that in the anterior region the myocardium is separated from the endothelium by a considerable space crossed by fine strands of protoplasm (text-fig. 17), while in the posterior portion the myocardium is closely applied to the endothelium (text-fig. 18). The transition between these two conditions takes place gradually in the region of the atrio-ventricular constriction of the right side.

Text-figure 18.



Perameles obesula (10.viii.03).

A. Transverse section through auricular portion of the heart.
B. Complete outline of same section.

End. Endothelium. *G.* Gut. *My.* Myocardium.

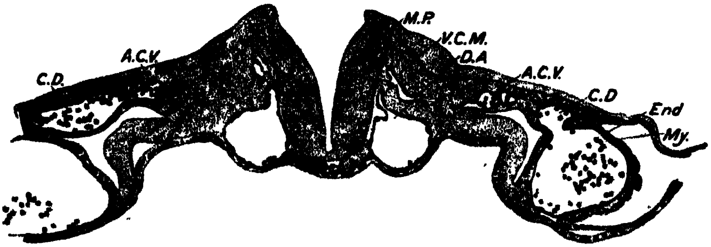
Turning now to the blood-vessels, two aortic arches are complete. Their relations are seen most clearly in the side view of the model (Pl. II. fig. 8, *A.* 1 & 2). From the ventral view (fig. 6) it will be seen that there are a number of capillaries lying against the gut-wall, between the roots of the right and left mandibular arches. These are probably derived from the scattered angioblast cells in the corresponding position in Stage III., and are doubtless destined to contribute to the formation of the median ventral aorta which is established in the next stage (Stage VI.). The first aortic arch runs forwards to the anterior end of the gut and is there connected by a well developed loop, situated laterally to the apex of the fore-gut, with the corresponding dorsal aorta. The aorta is paired throughout its length (Pl. II. fig. 7, *D.A.*). From the anterior convexity of the loop of the first arch there is given off on each side a vessel which runs outwards and forwards and then breaks up into series of capillaries which form a cup surrounding the primary optic vesicles. These capillaries run round the postero-lateral face of the optic vesicle to become connected dorsally with the veins of the head (fig. 7).

The second aortic arch arises from the dorsal side of the bulbus, runs backwards and outwards to loop round the gut in the hyoid arch and to join the dorsal aorta (see Pl. II. figs. 6–8, *A.* 2).

From the dorsal aortæ posterior to the second aortic arch, there arises a pair of small sprouts running outwards on the gut-wall. These are the dorsal elements of the third aortic arch.

The best developed venous trunk of the head, viz. the vena capitis medialis, is clearly seen in the dorsal view of the model (fig. 7, *V.C.M.*). Each is a small vein lying dorsal to the dorsal aorta close against the neural tube (text-fig. 17, *V.C.M.*). Anteriorly this vein runs into the dorsal aorta. In the model this is only shown on the left side, but high-power examination of the sections reveals a very fine capillary completing the connection between the right vein and the aorta. Arising from the vena capitis medialis in the anterior half of the mandibular arch is a series of capillaries which are continuous with those surrounding the optic vesicles. The brain here is widely open and its margin is situated just to the outer edge of the capillaries. The latter would accordingly lie medial to the neural crest were such present in this region. In the region of the first visceral pouch there is another line of capillaries lying lateral to the vena capitis medialis and connected with it. From the anterior end of these capillaries there runs outwards and forwards a vessel connecting them with a group of capillaries lying in the mandibular mesoderm lateral

Text-figure 19.

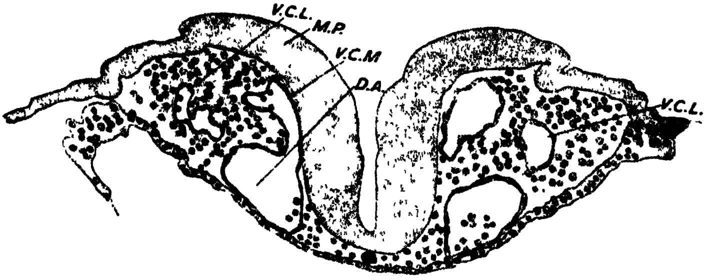


Perameles obesula (10.viii.03). Transverse section through the Cuvierian ducts.

A.C.V. Anterior cardinal vein. *C.D.* Cuvierian duct. *D.A.* Dorsal aorta. *End.* Endothelium. *M.P.* Medullary plate. *My.* Myocardium. *V.C.M.* Vena capitis medialis.

and ventral to the gut. The vena capitis medialis runs back alone for a short distance, and is then again connected with a more laterally situated capillary. This capillary runs back from this point to the level of the incipient third aortic arch, and then runs laterally to be connected with the Cuvierian duct which is now well developed (fig. 7 & text-fig. 19). On the right side of the embryo this transverse connection is very incomplete, but not quite so incomplete as would appear from the model, since the difficulty of building up these fine capillaries caused some to be lost in this region. This vein, lying lateral to the vena capitis medialis and to the primordia of the nerve-ganglia, is the vena capitis lateralis of Grosser (**6**) and Salzer (**17**). From the venæ capitis medialis and lateralis the anterior cardinal vein is derived. The auditory vesicle lies in the space between the venæ capitis medialis and lateralis immediately dorsal to the second aortic arch. Running in the hyoid arch are a few capillaries apparently corresponding with the much more conspicuous group in the mandibular arch.

Text-figure 20.



Perameles obesula (10.viii.03). Transverse section showing the connection of the vena capitis medialis with the dorsal aorta.

D.A. Dorsal aorta. *M.P.* Medullary plate. *V.C.M.* Vena capitis medialis. *V.C.L.* Vena capitis lateralis.

The Cuvierian ducts have increased considerably in size, and that of the left side opens direct into the lateral heart-tube (text-fig. 19, *C.D.*). Behind the opening of the Cuvierian duct a single small capillary runs posteriorly in the somatopleure representing the future umbilical vein. The vena capitis medialis, it should be noted, continues on after the lateral bend of the vena capitis lateralis (fig. 7). The two are closely connected in the region of the incipient third aortic arch.

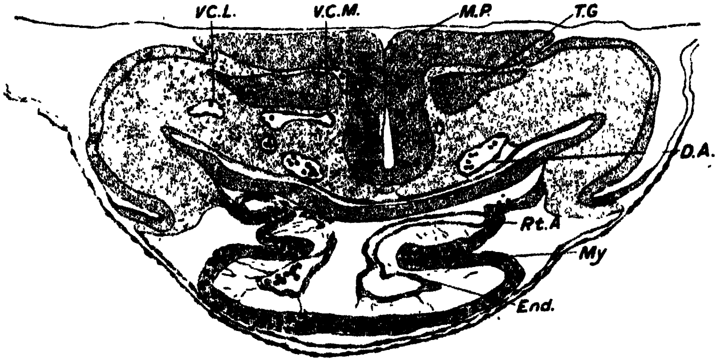
One important point which is difficult to observe in the figures of the model is shown in the sections of the embryo (text-fig. 20), and that is the fact that the vena capitis medialis at irregular intervals opens into the dorsal aorta.

In this stage, then, we find the ventricular and auricular portions of the heart differentiated. Fusion of right and left primordia has only affected the myocardium and the cephalic ends of the endothelial tubes. The two halves of the auricular portion of the heart are wide apart.

Two complete aortic arches are present and one is in process of formation. Venæ capitis medialis and lateralis and Cuvierian ducts are all present.

It is not necessary to give a detailed description of the embryo of *Macropus* sp., which is included in this stage, as it differs only in certain points from the *Perameles obesula* embryo described above. In the degree of development of the gut and pharyngeal pouches, as well as of the nervous system, the two embryos very closely resemble each other.

Text-figure 21.



Macropus sp. Transverse section through the root of the second aortic arch.

D.A. Dorsal aorta. *End.* Endothelium. *M.P.* Medullary plate. *My.* Myocardium. *Rt.A.* Root of aortic arch. *T.G.* Primordium of trigeminal ganglion. *V.C.L.* Vena capitis lateralis. *V.C.M.* Vena capitis medialis.

Two complete aortic arches are present, but there is no trace of a third.

The vena capitis medialis resembles that of the *Perameles* embryo. The vena capitis lateralis, however, is slightly less advanced, being only recognisable in the region of the trigeminal and facial neural crest proliferations, and not extending back as far as the auditory vesicle. Cuvierian ducts are present, and the right one at least opens into the heart-tube. The sections are somewhat broken in this region, so that satisfactory observations on the openings of the Cuvierian ducts and their relations to the anterior cardinal veins are impossible.

The heart differs in several respects from that of the *Perameles* embryo. The general relations of heart and pericardium and the mode of origin of the aortic arches are exactly the same in the two embryos. In the *Macropus* embryo, as in *Perameles*, the myocardium is fused in the middle line throughout the length of the closed gut. A slight groove marks the line of fusion in the posterior portion of the heart, but there is no indication of a ventral mesentery at any point. The ventricular region of the heart is distinguished from the auricular by the fact that in the ventricular portion a considerable space intervenes between endothelium and myocardium, whereas in the auricular portion the two layers are close together. The limit between the two divisions is further indicated by a constriction of each endothelial tube, which then widens out abruptly to form the auricle. Right and left endothelial tubes are united anteriorly in the region of the bulbus arteriosus, just as in the *Perameles* embryo. Behind this again they diverge around the opening of the gut. It may be noted that in the region of the widest divergence of the endothelial tubes a fine bridge runs across and connects the two.

The curvature, so far as it can be made out without reconstruction, is similar to that of the *Perameles* embryo. The asymmetry appears to be less marked than in the latter embryo, but on this point it is impossible to make a positive statement without reconstruction. Throughout a considerable portion of its length, however, the right endothelial tube is larger than the left, just as in the *Perameles* embryo.

The *Macropus* embryo then differs from the *Perameles* embryo of a similar stage mainly in the configuration of the endothelial tubes, which are joined at their cephalic extremity, then widely separate for some distance (text-fig. 21), and then again approximated, though not joined. This difference, as well as the slight differences in the myocardial wall, may very probably be due to slight dissimilarity in the positions of the endothelial tubes and the myocardium before union of the latter.

STAGE VI. *Macropus ruficollis.*

The material for this stage consists of a single embryo of *Macropus ruficollis*, cut transversely.

Greatest length of embryo, 5·2 mm.

Dorsal perimeter, about 13·5 mm.

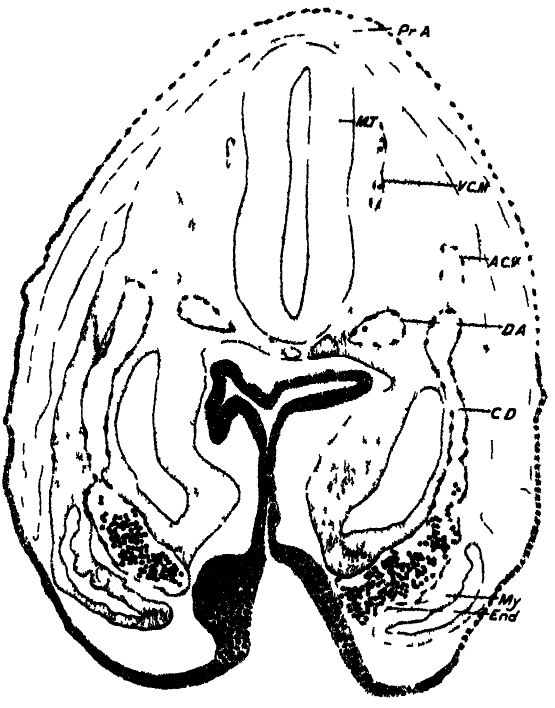
The embryo is sharply bent in front of the fore-limb buds, so that the head, invested by proamnion, is sunk down into the yolk-sac and forms an acute angle with the trunk. No trunk amnion is yet developed. The brain, though open in the fore- and mid-brains, is closed in the region of the hind-brain.

The gut is closed as far back as the third well-developed somite. Three visceral pouches are present.

The heart shows a considerable advance on the preceding stage. The right and left heart-tubes are fused except in the region of the sinus venosus, where they remain separate, while the Cuvierian ducts, which are now established as wide vessels, pass across the cœlomic cavity to open into the right and left heart-tubes (text-fig. 22).

Curvature of the median portion of the heart has resulted in the definite establishment of a U-shaped ventricular limb and an auricular portion extending from the left dorsal side of the ventricle posterior to its apex and separating, at the opening of the gut, into the right and left halves of the sinus venosus.

Text-figure 22.



Macropus ruficollis Transverse section through the Cuvierian ducts.

A.C.V. Anterior cardinal vein. *C.D.* Cuvierian duct *D A* Dorsal aorta. *End.* Endothelium. *M.T.* Medullary tube. *My.* Myocardium *Pr A.* Proamnion. *V.C.M.* Vena capitis medialis.

The cephalic portion of the S-shaped heart is somewhat curved, so that, as in the preceding stage, the bulbus (conus) arteriosus lies dorsal to the cephalic extremity of the ventricle. The bulbus arteriosus is continued into a short median ventral aorta which bifurcates to form the first pair of aortic arches. The second and third pairs of aortic arches arise from the median ventral aorta immediately posterior to its bifurcation. The second arch is large, the third very small.

In correlation with the rapid development of the fore- and mid-brains at this stage, the head-plexus found in Stage V. (see Pl. II. figs. 6–8) has become extended into a long slender vessel, destined to form the anterior part of the internal carotid artery and lying on either side of the mid-ventral line in the fore-brain region. As in the preceding stage, it anastomoses anteriorly with capillaries arising from the vena capitis medialis.

Both venæ capitis medialis (text-fig. 22, *V.C.M.*) and lateralis are present, though neither can be traced continuously throughout the head-region. The vena capitis medialis extends to the anterior end of the brain, lying close to the medullary tube, dorsal to the dorsal aorta and the internal carotid artery. It is discontinuous in the region of the auditory vesicle, where no veins are recognisable. Posterior to that, it runs back as a continuous trunk to the level of the Cuvierian duct, and beyond this is recognisable as a minute vessel lying close to the neural tube in the trunk region.

Lying lateral to the primordium of the trigeminal nerve, there are a few scattered capillaries which represent discontinuous segments of the vena capitis lateralis. Immediately posterior to the primordium of the trigeminus, the vena capitis lateralis arises from the vena capitis medialis and runs back as a small vessel lying lateral to the root of the facial nerve. Venæ capitis lateralis and medialis are interrupted in the region of the auditory vesicle, but both are present immediately posterior to it. At irregular intervals on their course there are transverse communications between the two veins. The vena capitis lateralis does not form a continuous trunk in the region posterior to the auditory vesicle, but immediately anterior to the point of separation of right and left heart-tubes it increases markedly in size and is connected by a wide anastomosis with the vena capitis medialis, which becomes very small posterior to this level. The enlarged vena capitis lateralis, or, as it may here be called, anterior cardinal vein, passes ventro-laterally and, running alongside the dorsal aorta for a short distance, finally opens into the Cuvierian duct in the manner seen in text-fig. 22.

The umbilical vein is now present, running in the somatopleure and opening into the Cuvierian duct.

In this stage, then, we have a heart in which fusion of the right and left primordia has occurred except in the region of the sinus venosus, and curvature has carried the auricular limb into position dorsal to the ventricle. Three aortic arches are present, venæ capitis medialis and lateralis are well established though discontinuous and open *viâ* the Cuvierian ducts into the sinus venosus.

SUMMARY AND DISCUSSION.

A. *Development of the Heart.*

From the foregoing description it is evident that the early development of the heart in such Marsupials as *Perameles* and *Dasyurus* proceeds along essentially the same lines as in Eutheria. The early stages of the heart development in the latter have been described by a number of investigators (*e.g.* Mollier (15)); but although the broad outline of the process may be said to be well known, there is still considerable difference of opinion with regard to certain points. It will be useful, therefore, before summarising the preceding observations, to briefly review the literature on the subject.

With regard to the lateral paired primordia of the heart little need be said at this point. The heart endothelium arises between the entoderm and the splanchnic mesoderm, from which latter it is either partially or wholly derived. The primordia of the heart-tubes are first recognisable in the hind-brain region and grow forwards at the expense of angioblastic cells proliferated off from the splanchnic mesoderm, which is itself thickened and indented to form the primordium of the myocardium. It should be noted that in the earliest stages examined (Pl. I. figs. 1 & 2) the endothelium lies to the medial side of the pleuro-pericardial canals in the anterior region and to the lateral side in the posterior region. To this point reference will be made subsequently in connection with the discussion of the reversal of the pericardium which, according to some authors, takes place at the time of formation of the head-fold.

The processes which bring the lateral heart primordia into position below the fore-gut relate primarily to the formation of the head-fold, and it is therefore necessary to get a clear idea of the mode of closure of the gut before considering the problems relating to the fusion of the lateral primordia of the heart.

Some authors (*e. g.* Robinson (13)) hold that the formation of the fore-gut is due mainly, if not entirely, to the rapid growth of the embryo over the relatively stationary line between the embryonal and extra-embryonal areas. Thus Robinson (13) says: "The orifice (of the umbilicus) is not reduced in size during the early stages of development by the convergence of its margins towards a central point. This being the case, no tucking off of the embryo from the surface of the ovum can occur; on the contrary, what does occur is almost the exact opposite of such a process, for the margin of the area remains as a relatively slow-growing region, whilst the embryonic and extra-embryonic portions of the wall of the ovum rapidly increase in extent. Under these circumstances, it follows that the margin of the embryonic area will soon appear as a ring between the upper or embryonic and the lower or extra-embryonic parts of the ovum, both of which have expanded beyond it in all directions."

While the forward growth of the brain-plate doubtless plays an important part in the initiation of the formation of the fore-gut, this explanation does not account for the conditions revealed by reconstructions of the gut and pericardium in the early stages of head-fold formation.

On the other hand, various investigators (*e. g.* Rouvière (**14**), Gräper (**4**)) contend that there occurs, in addition to the forward growth of the brain-plate, a backward progression of the anterior intestinal portal, whilst in older accounts an actual fusion of lateral folds in the mid-ventral line was assumed. Both Robinson (**13**) and Rouvière (**14**) give excellent reasons for regarding this assumption as erroneous. They point out that if gut-closure were effected by the fusion of lateral folds (such as are shown in text-fig. 9), the heart would remain in connection with the gut by a dorsal mesocardium and with the yolk-sac wall by a ventral mesocardium. Robinson denies the existence of a ventral mesocardium in mammals, and quotes this fact in support of his theory that the separation of the gut from the yolk-sac is due to growth of the embryo rather than to fold-formation. Rouvière, on the other hand, while he agrees with Robinson as to the absence of a ventral mesocardium in mammals, gives a different account of the process of gut-closure. He describes the formation of lateral pleuro-pericardial canals which grow forwards round the anterior end of the brain-plate and fuse to form a continuous cavity. The splanchnopleure forming the posterior wall of the pleuro-pericardial cavity now forms a continuous fold which Rouvière, following Tourneux, calls the "cardiac fold" (compare text-fig. 12, *C.F.*) and which he describes as growing actively backwards as a whole.

In the chick, on the other hand, a ventral mesocardium is present, but this is due, as Robinson points out, to the relatively late penetration of the mesoderm in the head region. The pleuro-pericardial canals do not extend round and unite in front of the medullary plate in early stages, but only at a later stage do they penetrate into the floor of the fore-gut after that has been formed. The lateral cavities therefore do not at once become continuous, but remain separated from each other by a double layer of mesoderm constituting the ventral mesocardium.

With regard to mammals, Rouvière, while he does not discuss the influence of the forward growth of the brain-plate, concludes that the crescent-shaped cardiac fold grows backwards as a whole, and that the free edge of the splanchnopleural fold progresses always in advance of the primordia of the heart, so that no fusion of the splanchnopleure is involved and no ventral mesocardium is formed.

Gräper, in a description of the growth processes in the developing chick, which he worked out by staining the living embryos and keeping them under observation while still alive, shows that there is considerable evidence in support of the view that the margin of the fore-gut (anterior intestinal portal) moves backward concurrently with the forward growth of the brain-plate. He gives a series of comparative measurements which show that the rate of removal of the lip of the anterior intestinal portal from the anterior end of the brain is greater than the rate at which the brain-plate grows forward from a given fixed point; hence it is evident that the anterior intestinal portal must be moving backwards.

Concurrently with the formation of the fore-gut, the lateral heart-tubes come to lie ventrally to it, but do not at once fuse. Wilson (**20**), in a paper on young human embryos, draws attention to this fact and refers to the embryo of *Perameles nasuta*, described in this paper as Stage III., as exemplifying this condition; but he does not discuss the question as to how these lateral hearts approach one another.

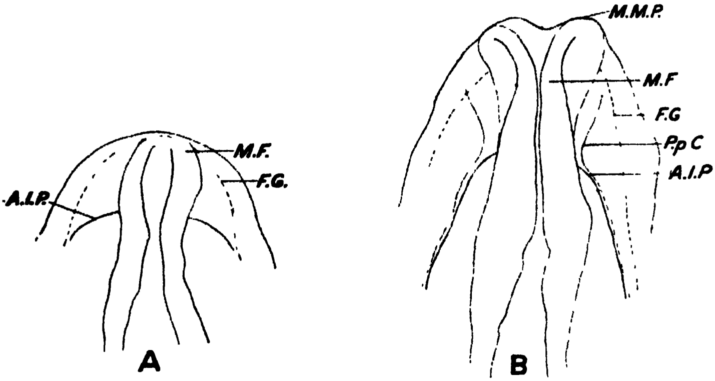
We may now consider the evidence afforded by the material described above, and will endeavour to show that it is entirely in accord with the view that there is actual backward growth of the anterior intestinal portal, and that it is this process, and not fusion of lateral folds, that brings about lengthening of the fore-gut.

It may be noted here that in *Perameles*, as in the rabbit (Rouvière), no ventral mesocardium is present at any stage, a fact which, in itself, is a strong argument against the theory that gut-closure is effected by the fusion of lateral folds.

If we compare a stage in which the head-fold has not yet appeared (Pl. I. figs. 1 & 2) with one in which a small portion of the fore-gut is differentiated (figs. 3 & 4), we see that the pleuro-pericardial cœlom not only moves backward relatively to the brain-plate but also increases very considerably in width. It is obvious that such an increase in size must either cause the pericardium to extend peripherally or to close in towards the axial line, and it is perfectly clear on comparison of figs. 2 & 3 that it is this latter process which is taking place. From a longitudinal section, such as is shown in text-fig. 4, it is evident, moreover, that such an expansion of the pericardium must involve the backward growth of the splanchnopleural floor of the fore-gut. If the lengthening of the fore-gut were due entirely to the rapid forward growth of the brain-plate, there would be no such inward closure of the pericardial region. Moreover, if we compare figs. 2 & 3 (Pl. I.), we see that in the earlier stage, the pericardial cœlom is situated peripherally to the margin of the brain-plate, while in the second stage, the inner margin of the pericardium lies in the lip of the anterior intestinal portal. Now the growth in length of the brain-plate in the period between these two stages would naturally give rise to a fold round its anterior margin, but would not bring the pericardium into the position it occupies in Stage II. (fig. 3), unless there occurred concurrently with such growth in length either an increase in width of the brain or an inward closure of the pericardium. Comparison of figs. 2 & 3 again shows that while no increase in width of the brain-plate has occurred, the pericardium has actually closed in towards the axial line. Precisely the same conclusion may be reached from a comparison of figs. 1 and 4, but as the interval between the stages is greater and the embryos are not of the same species, less importance attaches to them in this connection.

It has already been remarked that, in the chick, the development of the pleuro-pericardial canals occurs at a later period than in the mammal, so that in this type the form of the head-fold in early stages cannot be affected by growth of the pericardium. If we compare the shape of the fore-gut in a chick of two somites with that of *Dasyurus* Stage 11. (text-fig. 23 A & Pl. I. fig. 3), we see that in the first stage of head-fold formation in the bird, the outline of the anterior intestinal portal is broadly crescentic, while in *Dasyurus* it is U-shaped. This difference I conceive to be due to the fact that in the chick, no factor but the forward growth of the brain-plate is operating at this stage, while in the mammal, in addition to this process, the expansion of the pericardium is already bringing about the formation of lateral folds and the consequent narrowing of the anterior intestinal portal. A slightly later stage of the chick (text-fig. 23 B) shows an approximation to the mammalian condition, for the pleuro-pericardial canals have appeared and are progressing towards the middle line; lateral folds have therefore arisen and the outline of the anterior intestinal portal is U-shaped.

Text-figure 23.



Anterior end of chick of (A) 2 somites, (B) 4 somites, to show the relations of the head-fold, brain-plate, anterior intestinal portal and pleuro-pericardial cavities.

A.I.P. Anterior intestinal portal. *F.G.* Fore-gut (outline). *M.F.* Medullary fold. *M.M.P.* Margin of the medullary plate. *P.p.C.* Pleuro-pericardial cavity.

We may therefore conclude, that while the forward growth of the brain-plate initiates the formation of the head-fold, there occurs concurrently with this process in the mammal, and at a slightly later stage in the chick, a rapid expansion of the pericardium and a consequent backward and inward growth of the fold of splanchnopleure which constitutes the inner margin of the pleuro-pericardial cavity.

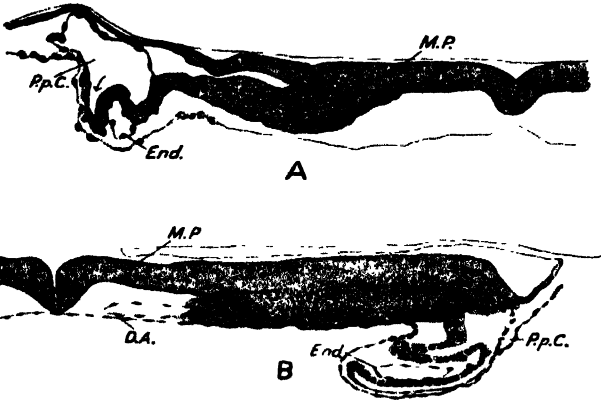
Additional evidence is afforded by the study of the longitudinal sections and reconstructions of Stages III. & IV. (text-figs. 12 & 15; Pl. I. figs. 4 & 5). From the longitudinal sections, it is evident that a great increase in length of the brain has occurred in the mid- and fore-brain regions. If, therefore, the increase in length of the fore-gut were due to elongation of the brain-plate, a corresponding increase should occur in the portion of the fore-gut lying below these segments, *i. e.* the portion anterior to the first visceral pouch in Stage III. (fig. 4). Comparative measurements of the gut in figs. 4 & 5 show, however, that no increase in length has occurred anterior to the first visceral pouch. Moreover, growth of the medullary plate would not necessarily bring about lengthening of the fore-gut unless it occurred along a straight line representing the longitudinal axis of Stage III., *i. e.* unless the brain remained unflexed. The positions of the auditory neuromere in fig. 4 (opposite the second visceral pouch) and fig. 5 (opposite the first visceral pouch), show that the brain-plate has moved forward relatively to the gut between Stages III. & IV. If, now, we study the longitudinal section of Stage IV. (text-fig. 15) we see the conditions resulting from the increase in length and forward growth of the brain-plate. The gut has increased in dorsi-ventral extent, the medullary plate projects considerably anterior to the cephalic limit of the gut, and flexure has occurred at two points; that is to say, the rapid growth of the fore- and mid-brains, instead of involving a longitudinal stretching of the portion of the gut lying ventral to them, has caused little or no increase in length of the embryo along its straight long axis: the additional extent of the brain-plate is accommodated within the limited space by flexure.

We see, therefore, that although the brain-plate lengthens rapidly after the first establishment of the head-fold, we can safely conclude that this does not cause elongation of the gut, for the regions of greatest growth of the gut and brain-plate are not correlated and the value of the forward growth of the brain as a factor in the lengthening of the fore-gut is largely rendered nugatory by the occurrence at this period of the cranial flexure.

On the other hand, there is little difficulty in interpreting the progressive closure of the gut at this stage as being due to an entirely different cause, for the median pericardium has extended rapidly, its antero-posterior length in the middle line having more than doubled in the short developmental period elapsing between Stages III. and IV. (Pl. I. figs. 4 & 5). As the anterior margin of the pericardium is in contact with the ectoderm of the head-fold, the rapid expansion of the cavity naturally involves a closure inwards, towards the axial line, of the fold of splanchnopleure limiting the gut.

It is necessary now to consider the early development of the heart in relation to the mode of closure of the gut described above. It is evident, as Rouvière points out, that if gut-closure be effected by the backward movement of the cardiac fold, no ventral mesocardium will be formed at any stage in forms, such as mammals, in which a continuous pericardial cavity is present prior to head-fold formation. It remains to be considered how the lateral primordia of the heart reach their position in the dorsal wall of the median pericardium. Various authors, *e. g.* Robinson **(13)**, have assumed that as the head fold forms, the pericardium undergoes a complete reversal, so that its anterior wall becomes posterior and its ventral wall, dorsal. Of such a process of reversal, the longitudinal sections figured here (text-figs. 4, 5 & 12) give no evidence. Moreover, in the anterior region of the pericardium, the primordium of the heart on each side of the embryo lies at or near the inner, medial margin of its pleuro-pericardial canal, so that a reversal which affected the anterior limb of the pericardium would indeed bring the heart primordia into position ventral to the gut, but would carry them also to the lateral margins of the gut, a position which they do not occupy.

Text-figure 24.



Transverse sections through embryos of *Dasyurus viverrinus*, (A) Stage I. (7·5 mm.), (B) Stage II. (8·5 mm.), to show the direction of extension of the pericardial cavity.

D.A. Dorsal aorta. *End.* Endothelium. *M.P.* Medullary plate.
P.p.C. Pleuro-pericardial canal.

On the other hand, if we take into consideration the fact that the heart primordia lie at the medial margin of the pleuro-pericardial canals, we see that the inward progression of the edge of the splanchnopleural fold in the direction indicated by an arrow in text-fig. 24 A, will bring about the conditions shown in text-fig. 24 B. (Compare also text-fig. 8, where the relations are essentially the same and probably approximate more closely to those in the living embryo.)

From this stage, it is evident that when the lateral limbs of the pleuro-pericardial canals become incorporated in the median pericardium by the backgrowth of the cardiac fold, the heart primordia will lie in the dorsal wall of the pericardium and will be situated towards the middle line of the gut. (See text-fig. 8.) Thus, as Rouvière (**14**) indicates in describing similar conditions in the rabbit, the position of the heart primordia in such a stage as is represented in text-fig. 24 B, is brought about "by the inward extension of the lateral prolongations of the cardiac fold." There is no evidence of reversal of the pericardium, nor is there adequate ground for assuming that such a process occurs.

We can, therefore, gain a clear conception of the way in which the lateral heart primordia attain the position they occupy in Stage III. (Pl. I. fig. 4; text-fig. 8) lying side by side below the closed fore-gut.

In order to complete the history of the early development of the heart, it is now necessary to consider the mechanism which brings the heart-tubes into contact in the middle line.

If we compare figs. 4 and 5 (Pl. I.) we see at once that while the pericardium has increased rapidly in the antero-posterior direction, it has not increased in transverse width and, in fact, at the point of closest approximation of the heart-tubes, an actual decrease in width has occurred; that is to say, the pericardium at this stage is growing in the antero-posterior direction at the expense of its transverse width. This fact suggests a simple explanation of the approximation of the heart-tubes after gut-closure, for it may be supposed that if the total width of the pericardium is reduced by this process of stretching, the distance between the heart-tubes will decrease until they meet each other in the middle line *.

The heart-tubes, in the period following immediately on their reaching the middle line, grow very rapidly, so that, in the next stage (V.), we find various forms of curvature which serve to accommodate the increased length of the heart. In the embryo of *Perameles obesula* described in this stage (Pl. II. fig. 6), the heart-tubes are in contact through a great portion of their length and here follow a parallel curved course. The separate heart-tubes lying in the lips of the anterior intestinal portal, however, show a marked difference from each other both in their length and the form of curvature, the right primordium being larger and more markedly curved than the left. This asymmetry occurs to a somewhat less extent in the *Onychogale* embryo of this stage, and also in a number of embryos of *Dasyurus viverrinus* of about the same stage, so that evidently at this period the right and left primordia of the heart develop independently of each other. It may be suggested that the greater length of the right heart-tube is to be accounted for by the fact that it is destined to form the convex, longer side of the completed ventricular limb.

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* The suggestion that the approximation of the heart-tubes is due to such a growth in length without compensatory growth in width was made to me by Professor Hill.

B. *Development of the Cardinal Veins.*

Before summarising the results of my observations on the development of the cardinal veins, more particularly the anterior cardinals, it may be useful to give a short resumé of previous work in this field.

Hoffmann (**7**) in 1893 described the development of both anterior and posterior cardinals in Selachians by the formation of a series of offshoots from the dorsal aortæ. These offshoots become connected on each side to form a continuous longitudinal trunk. He figures capillaries lying on both medial and lateral sides of the auditory vesicle, but makes no comment thereon.

Salzer (**17**) in 1895 described the development of the anterior cardinal veins in the guinea-pig. According to him, the first vein of the head arises on the medial side of the cranial ganglionic primordia. A vein next arises lying lateral to the ganglionic primordia of nerves VII., IX. & X. and to the auditory vesicle. This vein, which Salzer calls "vena capitis lateralis," communicates with the medial vessel and seems to be formed from a series of lateral outgrowths from it. The medial vessel degenerates in the region of nerves VII. to X., so that for a time there is a condition in which the vein of the head runs medially to the trigeminal nerve, then, passing laterally, runs outside nerves VII., IX. & X. and the auditory vesicle, and finally passes round the medial side of nerve XII. before opening into the Cuvierian duct. In subsequent stages, the process of development of the lateral trunk is continued anteriorly and posteriorly in the region of the trigeminal and hypoglossal. Thus the definitive anterior cardinal vein runs laterally to all the cranial nerve-roots.

Grosser (**6**) in 1907 gave a similar description of the development of the anterior cardinals throughout the vertebrate series. He calls the vein lying medial to the nerve-roots the *vena capitis medialis*, and the lateral vessel the *vena capitis lateralis*. The former develops first and lies close against the neural tube. From it are given off lateral vessels which become connected on the outer side of the nerve-roots to form the vena capitis lateralis. The vena capitis medialis persists only at its anterior end, the rest of the anterior cardinal being derived from the vena capitis lateralis.

Turning now to the facts revealed by the foregoing study of *Perameles*, we find both the venæ capitis medialis and lateralis present. In Stage III. the first traces of the venous system of the head are present in the form of isolated segments of the vena capitis medialis. Further, in this stage, in the region of the somites, there is on each side a series of dorsal offshoots from the dorsal aorta (text-fig. 11) partially connected to form an as yet incomplete longitudinal vessel lying, like the vena capitis medialis, close against the neural tube. This vessel Hoffmann (**7**) described as representing the primordium of the posterior cardinal vein. It is worthy of note that whilst the origin of this vein from the dorsal aorta is thus clearly demonstrated, no connection between the anterior segments of the vena capitis medialis and the dorsal aorta could be observed, even after careful study of the individual sections under the high power. In the next stage (IV. *P. nasuta* 2 P), however, the vena capitis medialis, though not forming a continuous longitudinal trunk, is recognisable throughout the head region and is connected at irregular intervals with the dorsal aorta. Furthermore, the vena capitis medialis in this stage gives off lateral capillaries which anastomose to form the primordium of the vena capitis lateralis. In the somitic region we find again a series of intersegmental offshoots from the dorsal aorta. The venæ capitis lateralis and medialis continue to develop side by side, giving rise to the condition shown in Pl. II. fig. 7 (*V.C.L.* and *V.C.M.*). (See also text fig. 25.) In this stage the dorsal aorta and the vena capitis medialis are connected by small capillaries (see text-fig. 20) whilst anteriorly the two vessels pass into continuity with each other *. From the material available it is not possible to say definitely how these connections arise, but the facts suggest that the vena capitis medialis is derived from the dorsal aorta. This view is further supported by the existence in the trunk region of a longitudinal vessel which is undoubtedly formed from a series of outgrowths from the dorsal aorta (text-fig. 11). This vessel apparently bears the same relation to the posterior cardinal that the vena capitis medialis does to the anterior cardinals, *i. e.* it gives origin to capillaries which contribute to the formation of the posterior cardinal. The origin of the vena capitis medialis from the dorsal aorta cannot, however, be regarded as proved, for in the first stage in which it is recognisable, no connection with the dorsal aorta could be traced; in the two following stages (IV. and V.) the connection is established and is lost in all subsequent stages (*e. g.* VI.).

From the descriptions of Salzer (**17**) and Grosser (**6**) it seems that in the forms which they have studied, the vena capitis medialis fuses in its entirety with the vena capitis lateralis, and the anterior cardinal vein formed by the fusion of these two vessels passes ventro-laterally to open into the Cuvierian duct. This description is not, however, applicable to *Perameles*. In Stage V. (Pl. II. fig. 7) the vena capitis medialis is continued backwards into the trunk region of the embryo. The vena capitis lateralis lies parallel with it and communicates with it repeatedly in the anterior region; it then diverges from it and constitutes here the vessel usually known as the anterior cardinal vein, opening into the Cuvierian duct. The posterior prolongation of the vena capitis medialis continues as a small vessel lying alongside the neural tube in the trunk region. The Cuvierian duct arises as a relatively large vessel lying in the somatopleure dorsal to the posterior portion of the lateral heart-tubes. From its posterior extremity there runs back a series of capillaries which anastomose with capillaries arising from the prolongation of the vena capitis medialis. From this line of capillaries, which thus

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* Professor Hatta tells me that he has found this condition also in the embryo of the lamprey.

Text-figure 25.

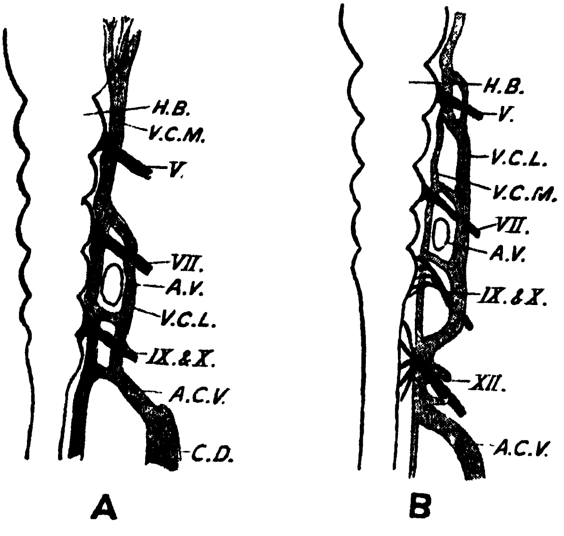

Diagram of the relations of the venæ capitis medialis and lateralis to the primordia of the nerves. Viewed from the dorsal aspect.

A. Stage V. *Perameles obesula* (10.viii.03). B. Stage with twelve cranial nerves, *Perameles nasuta* (13.vii.05).

A.C.V. Anterior cardinal vein. *A.V.* Auditory vesicle. *C.D.* Cuvierian duct. *H.B.* Hind-brain. *V.C.L.* Vena capitis lateralis. *V.C.M.* Vena capitis medialis. *V.* Trigeminal nerve. *VII.* Facial nerve. *IX.* & *X.* Common root of glosso-pharyngeal and vagus nerves. *XII.* Hypoglossal nerve.

shows a double origin, the posterior cardinal vein is undoubtedly derived, but the details of the process of development of the postcardinals cannot satisfactorily be worked out in the material available. The above account, however, agrees with that of Evans (**2**) for the chick with regard to the origin of the postcardinal from capillaries derived partly from the Cuvierian duct and partly from a vessel lying close to the neural tube.

The vena capitis lateralis in Stage V. is connected anteriorly with the primary head capillaries arising from the first aortic arch and also with groups of capillaries in the mandibular and hyoid arches (see Pl. II. figs. 6-8).

In subsequent stages, the development follows the course described by Salzer (**17**) and by Grosser (**5**). Thus in a stage in which twelve cranial nerves are established (*Perameles nasuta*, 13. vii. 05), the anterior cardinal vein runs medial to nerves V. and XII. and lateral to VII., IX., and X., and to the auditory vesicle (text-fig. 25 B); *i.e.*, the portion in the region of and anterior to the trigeminal nerve and also that posterior to the vagus, is derived from the original vena capitis medialis, the intervening portion from the vena capitis lateralis. Traces of the vena capitis medialis are, however, still present on the medial side of nerves VII., IX., and X.

Florence Sabin (**16**), in a recent note on the development of cardinal veins in the chick, supports the view that the cardinal veins are derived from the dorsal aorta. She, however, states: "The part of the head vein which lies close to the neural tube arises from the arch of the aorta and is a part of the vascular system of the central nervous system; the caudal part of the head vein arises directly from the aorta." In this respect my results differ somewhat from hers, for in *Perameles* the vena capitis medialis (*i. e.* "the part of the head vein which lies close to the neural tube") is present before there is any trace of the capillaries arising from the arch of the aorta (Stage III.). It is indeed secondarily connected with these, but as is shown in Pl. II. fig. 7 (*V.C.M.*) it also extends up to the extreme anterior end of the head in close relation to the dorsal aorta with which, in fact, it fuses. Since this vein exists before the formation of the head capillaries which connect it with the arch of the aorta, it obviously cannot be derived from that arch.

In seems, therefore, that in Selachians (Hoffmann (**7**)), the chick (Evans (**2**), Florence Sabin (**16**)), and also in *Perameles* and *Macropus*, there exists in the primary condition a continuous vessel lying close to the nerve-cord throughout its length. This vessel is derived in the posterior and probably also in the anterior region from the dorsal aorta. It contributes to the formation of both anterior and posterior cardinal veins.

It may be concluded that the presence in early stages of a vein lying close against the neural tube throughout its length is correlated with the relatively great importance of the central nervous system in these stages. The brain and spinal cord, being the first organs to attain any considerable degree of development, are naturally the first to receive a vascular supply, and both venæ capitis lateralis and medialis persist for some time, forming a rich supply of capillaries to the brain and surrounding the developing cranial nerves.

FINAL SUMMARY AND CONCLUSIONS.

The facts revealed by the study of early stages in the development of Marsupials point to the conclusion that while the initiation of head-fold formation is in all probability due to the forward growth of the brain-plate, there occurs also an active backward growth of the anterior intestinal portal. This process is associated with the rapid expansion of the pericardium which occurs at this period of development, and which brings about the backward and inward growth of the layer of splanchnopleure limiting the pericardium.

In the course of this inward closure, the pericardial cavity extends to the ventro lateral and finally to the ventral side of the lateral primordia of the heart, so that when the lateral portions of the pericardium become incorporated in its median limb, the heart primordia lie in the dorsal wall of the pericardium.

The approximation of the heart-tubes after gut-closure is due to the fact that, at this period, the pericardium grows rapidly in length and decreases in width so that the heart-tubes are brought together by longitudinal stretching of the pericardial wall lying between them.

Curvature of the heart is due to its rapid growth at a period of less active extension of the pericardium.

The first two aortic arches in *Perameles* are typical, and the development of the veins of the head resembles that process in other mammals in that the anterior cardinal vein is derived from persistent portions of two primitive head-veins, the venæ capitis medialis and lateralis. The posterior continuation of the vena capitis medialis also contributes to the formation of the posterior cardinal vein and is itself derived from the dorsal aorta.

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EXPLANATION OF THE PLATES.

Lettering.

A.	Auricle.
*A.*1, *A.*2, *A.*3.	First, second and third aortic arches.
A.C.	Angioblast cell.
A.C.V.	Anterior cardinal vein.
A.I.P.	Anterior intestinal portal.
A.N.	Auditory neuromere.
A.V.	Auditory vesicle.
A.V.C.	Auriculo-ventricular constriction.
B.A.	Bulbus arteriosus.
C.D.	Cuvierian duct.
D.A.	Dorsal aorta.
End.	Endothelium of heart.
F.G.	Fore-gut.
G.	Gut.
H.B.	Hind-brain.
I.C.	Internal carotid artery.
M.M.P.	Margin of the medullary plate.
My.	Myocardium.
P.	Pericardium.
P.p.C.	Pleuro-pericardial canal.
T.G.	Trigeminal ganglion.
V.	Ventricle.
V.C.L.	Vena capitis lateralis.
V.C.M.	Vena capitis medialis.
*V.P.*1., *V.P.*2.	First and second visceral pouches.

PLATE I.

Figures 1–5 represent graphic reconstructions of the anterior ends of five embryos, viewed from the ventral aspect and all drawn at the same magnification.

The outline of the gut is indicated by a broken line and its area is stippled, except where it is covered by the pericardium. The limits of the pericardium are indicated by a fine black line and its area is coloured grey. The endothelial heart-tubes, the aorta and the aortic arches are coloured red. The outline of the brain-plate is shown as a heavy black line wherever it was possible to determine its limits. In the region of the neural-crest proliferation in Stage I., the margin of the medullary plate is indistinct; a dotted line here indicates its probable outline.

The outlines of the gut, pericardium, and brain-plate were plotted on one side only, and the second side is a duplicate of the first, except in the case of figure 1 (*Perameles obesula* 1 Z), where the pericardium was plotted on both sides, as in this instance only was any marked asymmetry observed.

Fig. 1. Stage I. *Perameles obesula* (1 Z).
2. ,, I. *Dasyurus viverrinus* (7·5 mm.).
3. ,, II. *D. viverrinus* (8·5 mm.).
4. ,, III. *P. nasuta* (1 S).
5. ,, IV. *P. nasuta* (2 P).

PLATE II.

Figures 6–8 represent three views of the wax model of the heart and gut of *Perameles obesula* (10.viii.03) Stage V. The gut is painted white, heart endothelium and arteries red, veins and most of the capillaries blue, and myocardium yellow.

These three figures were painted by Miss E. A. Steele.

Fig. 6. Ventral view of model of *P. obesula* (10.viii.03).
7. Dorsal view.
8. Lateral view.

36. On Spiders of the Family Salticidæ collected by the British Ornithologists' Union Expedition and the Wollaston Expedition in Dutch New Guinea. By H. R. Hogg, M.A., F.Z.S.

[Received and Read May 25, 1915.]

(Text-figures 1 11.)

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The spiders herein described complete the record of the collections made by the above named Expeditions kindly entrusted by the promoters to my care. The paper in which I described the bulk of the collection appeared in Vol. XX. Part 14, of the Transactions of this Society.

This interesting addition to our previous knowledge includes some very beautiful forms of the exquisitely spangled varieties which in their small bodies rival the coloration of the brilliant bird fauna in which New Guinea is so rich. In spite of the considerable amount of work devoted of late years by many able contributors to collections brought from that country, it is evident that much remains for future explorers before its numerous species are exhausted. The proportion of new forms to those already known among these is about three to one.

Family SALTICIDÆ.

Section **Pleuridentati.**

Group BOETHEÆ.

BOETHOPORTIA, gen. nov.

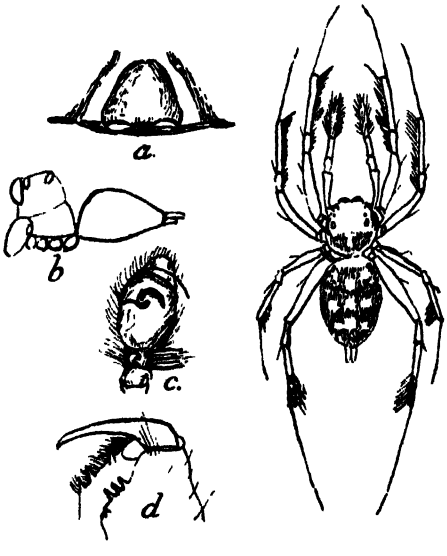
Boethoportia differs from *Portia* Karsch in having the front row of eyes straight along the upper edges and the rear row as wide as the front row, and from *Boetheus* in having the femur, patella, and tibia of the first pair of legs stouter than the others, fimbriations of long bristles at least on the tibia of the same, and the metatarsi and tarsi of all legs very fine, the former at least as long as the tibiæ.

BOETHOPORTIA OCELLATA, sp. n. (Text-fig. 1.)

1 male and 1 female. (*Types of the species.*)

Female. The cephalothorax is bright chestnut-red, black round the eyes with sparse white hairs; mandibles red-brown with pale red fangs; lip and maxillæ red-brown, paler at the front edges, with yellowish-grey fringes. Sternum also red-brown with yellowish-grey hair. Coxæ red-brown; femora brown underneath, with yellow patches on the upper side; tibiæ brown, with a yellow band in the middle and long brown bristly fringes. Metatarsus and tarsus yellow, with here and there patches of white hair. The abdomen pale yellow at the base, the remainder with large greyish-yellow spots on a brown gound; the underside is also brown with yellow spots, the hairs greyish-yellow on the pale parts, brown on the darker portions.

Text-figure 1.



Boethoportia ocellata, gen. et sp. n., ♀.

a., epigyne; *b.*, profile; *c.*, male palp; *d.*, mandible showing teeth.

The cephalic part of the cephalothorax is flat over the eye-space, slightly sloping forwards, from the eyes it slopes steeply down to the margin at the sides and rear. The thoracic part is barely one-half the length of the cephalic, and the rear slope is deeper than the whole length of the cephalothorax.

The front median eyes project forward on black rims. They are three times the diameter of the laterals, which stand back somewhat, but are level with the former along the upper margins. The eyes of the rear row are of the same size as the front laterals. The usually small eyes of the median row have a diameter two-thirds the length of these; they are rather nearer to the front lateral than to the rear eyes and are somewhat closer together than either.

The abdomen is broadly ovate, straight and widest in front; the spinnerets are terminal, the superior having a conical second joint. The epigyne is roughly triangular, rounded at the apex and incurved in the middle of the base-line, with horizontal oval apertures at the lower corners.

Male. Similarly coloured to the female.

The measurements (in millimetres) are as follows: –

Female.

	Long.	Broad.
Cephalothorax...	3½	2½ in front. 3½ 4 high at rear.
Abdomen..... ...	6	4
Mandibles	2	

		Coxa.	Trochanter & femur.	Patella & tibia.	Metatarsus & tarsus.		
Legs	1.	1¼	4½	5	5	=	15¾
	2.	1	4	4½	4¾	=	14¼
	3.	1	3¼	3½	4	=	11¾
	4.	1	5	5½	7	=	18½
Palpi		½	2½	2	2½	=	7½

Male.

	Long.	Broad.
Cephalothorax...	3	2½
Abdomen.........	4	1¾
Mandibles	1½	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	¾	3½	4	4	=	12¼
	2.	¾	3	3½	3¾	=	11
	3.	¾	2½	3	3	=	9¼
	4.	1	3½	4	6	=	14½
Palpi		½	1½	½	1½	=	4

Group DIOLENIEÆ.

Genus DIOLENIUS Thor.

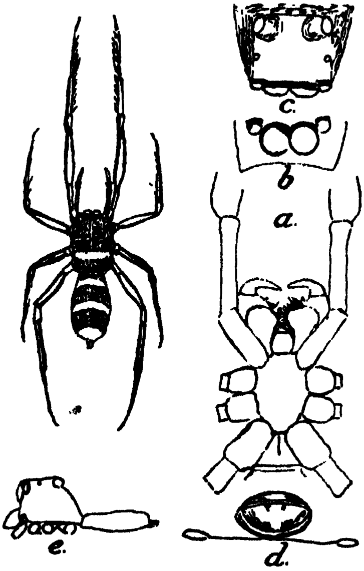
Thorell, European Spiders, 1870, p. 203.
E. Simon, Hist. Nat. des Ar. vol. ii. 1901, p. 480.

DIOLENIUS ALBOPICEUS, sp. n. (Text-fig. 2.)

1 female. (*Type of the species.*)

Female. The ground-colour of the cephalic part is black-brown with white hair at the sides and round the eyes, greyer and finer inside the eye-square. The outer margin of the thoracic part is dark yellow-brown, but across the middle is a broad white-haired transverse stripe.

Text-figure 2.



Diolenius albopiceus, sp. n., ♀.

a., sternum, coxæ, and trochanters; *b.*, eyes from in front; *c.*, eyes from above; *d.*, epigyne; *e.*, profile.

There are also three unbroken wide transverse stripes across the abdomen, one near the front, one in the middle, and one at the posterior end.

There are seven pairs of spines on round roots on the under side of tibia i., but no row of long hairs between them as in *D. amplectens*, and five pairs of spines under metatarsus i.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	$2\frac{3}{4}$	$1\frac{1}{2}$ in front. $1\frac{3}{4}$
Abdomen.........	$3\frac{1}{2}$	2
Mandibles	$\frac{3}{4}$	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1	$1\frac{1}{2}$ $2\frac{3}{4}$	$3\frac{1}{4}$	3	=	$11\frac{1}{2}$
	2.	$\frac{1}{3}$	$2\frac{1}{4}$	2	2	=	$6\frac{7}{12}$
	3.	$\frac{1}{2}$	2	2	2	=	$6\frac{1}{2}$
	4.	$\frac{1}{3}$	$2\frac{3}{4}$	3	3	=	$9\frac{1}{12}$
Palpi		$\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{3}{4}$	=	$2\frac{3}{4}$

Of the half-dozen somewhat similar species described by Thorell from New Guinea and the neighbourhood, this is nearest to *D. amplectens* Thor. (Ragni Aust.-Malesi, 1881, p. 412 *et seq.*). It differs therefrom in having the front row of eyes more recurved, the line touching the upper edges of the median cutting the side eyes at a point near the lower margins; the diameter of the median is slightly more than twice that of the side eyes.

It differs from *D. phrynoides* Walck. in having the tibia of the front pair of legs cylindrical instead of club-shaped, and without any fimbriation on the under side.

D. fasciatus Thor., the coloration of which is somewhat similar, has (according to that author) eight pairs of stout spines under tibia i. and only two pairs under metatarsus i.

Section **Unidentatæ**.

Group CHRYSILLEÆ.

Genus TELAMONIA Thor.

Thorell, Ann. Mus. Gen. ser. 2, vol. v. 1887, p. 385.
E. Simon, Hist. Nat. des Ar. vol. ii. 1901, p. 552.

TELAMONIA VIDUA, sp. n. (Text-fig. 3.)

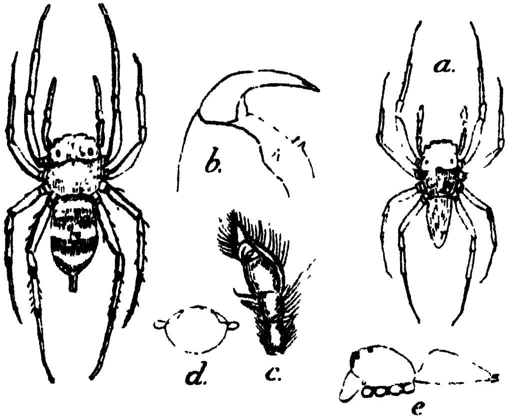
1 female. (*Type of the species.*)

Female. The cephalothorax is black, sparsely covered with white squamous hairs and upright black and white bristles over the eye-space, on the clypeus they are greyish-white. The mandibles are black, paler about the falx-margin, the fangs dark red-brown. Lip, maxillæ, and sternum black-brown with greyish hair. The legs yellow-brown underneath, the coxæ quite bright yellow, but the first three pairs of femora are dark yellow-brown on the upper side. The abdomen is black above with upright grey hairs and bristles, a white area of squamous hairs at the base, and two similarly haired transverse bands broken in the middle, one about the middle and the other near the posterior end. On the under side, a black oblong area with a pale yellow-brown border reaches to the sides.

The eye-space slopes forward and covers about two-fifths the length of the cephalothorax. The latter is convex, high, and slopes from the rear eyes to the posterior margin.

The rather large triangular tooth on the inner margin of the falx-sheath, though not far from the base of the fang, terminates the chitinous rim, the margin being cut away below it. The two teeth on the outer margin are further down and stand at the normal end of the same. The abdomen is ovate, rounded in front, and tapers at the posterior end.

Text-figure 3.



Pelamonia vidua, sp. n., ♀.

a., male ? ; *b.*, mandible showing teeth ; *c.*, male palp ; *d.*, epigyne ; *e.*, profile.

The rear row of eyes is not quite so broad as the front row, and narrower than the cephalothorax at the point where it crosses the latter. The front row is recurved ; the side eyes half the diameter of the median, standing a little away from the latter. The lip is longer than broad ; the maxillæ, upright, rounded anteriorly, and thickly covered with bristly hair, are less than twice as long as the lip. The sternum is ovate, truncate in front, where it is twice as wide as the base of the lip.

Under metatarsus i. are two pairs of spines, one near the base and another at the anterior end. There are two spines above on femur iv., one small on the outer side of the patella, two pairs on the tibia, two single ones on the outer side and a bunch at the anterior end of the metatarsus, all of moderate size.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	4	2½ in front. 3½
Abdomen ..	5	3
Mandibles	2	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1	3½	4	3¼	=	11¾
	2.	1	3	3¼	2¾	=	10
	3.	1¼	3	3¾	3¾	=	11¾
	4.	1½	3¾	4¼	4¼	=	13¾
Palpi		½	2	1½	1¼	=	5¼

Male. A somewhat broken specimen, almost similar in colouring to the above, appears to be of the same species but, as in other cases, the first pair of legs is the longest instead of the fourth. The shape of the cephalothorax and positions of the eyes are similar as also the falx-sheath teeth, but the lip is rather broader, making it as broad as long. The coxæ have thick white hairs at the ends adjoining the trochanters.

The white pattern on the back of the abdomen is formed of scales in two rows of rather large spots disposed longitudinally instead of transversely, and the pale bordering on the under side is less distinct than in the female. There is a row of eleven spines on the anterior half of tibia i. underneath as in *T. trabifera* Thor. and allied species.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	3½	2¼ in front. 2½
Abdomen... . .	3½	1½
Mandibles	1	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs .. .	1.	1½	3½	3½	3	=	11½
	2.	1	3	2½	2¼	=	8¾
	3.	1	2½	2½	2¾	=	8¾
	4.	1	3	2¾	3	=	9¾
Palpi		½	1¼	¾	1	=	3½

In 'Ragni di Selebes,' p. 251, Dr. T. Thorell described a male from Kandari which he named *Telamonia* (*Moeria* C. L. Koch, 1848) *latruncula*. This is apparently very closely akin to the above female, but differs in having a white marginal fillet round the cephalothorax, and elsewhere being brightly coloured red, blue and green, and having the lip 1½ longer than broad. The legs are shorter, but in about the same proportion as in this female.

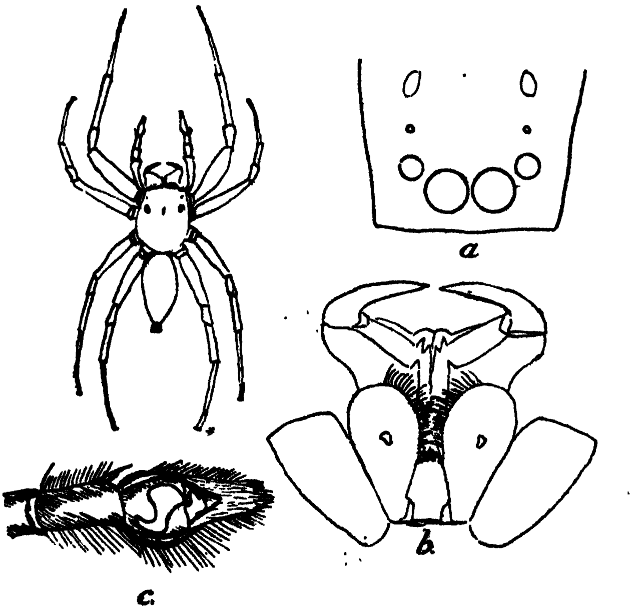
Either that or the above described male appears near enough to belong to the female, but of course the pair above described is known to be from the same neighbourhood.

TELAMONIA MANDIBULATA, sp. n. (Text-fig. 4.)

1 male. (*Type of the species.*)

Male. Cephalothorax black-brown, with white squamules over the eye-space interspersed with a few upstanding black bristles; the mandibles are black-brown. The lip and maxillæ brown with reddish fringes. The sternum dark brown with greyish-white hair. Of the coxæ, which are all contiguous, the first pair are brown, the remainder bright yellow. The abdomen is black-brown on the upper side, with upstanding white bristly hairs and a fillet of white squamules round the base and sides; inside this are two rows of large spots of the same arranged longitudinally from a little before the middle to the rear end; underneath it is a dull yellow-grey. The front pair of legs is brown all over

Text-figure 4.



Telamonia mandibulata, sp. n., ♂.

a., eyes; *b.*, mandibles, lip, and maxillæ; *c.*, male palp.

with the exception of a pale yellow ring at the distal end of the tibial joint. The other legs are yellower. They are all sparsely furnished with white almond-shaped scales and upstanding pale yellow-brown hairs. The palpi are as dark as the first pair of legs.

The cephalothorax is about one-fifth longer than broad, flat on the eye-space, highest at the level of the rear row of eyes, whence it slopes slightly forward and steeply to the margin all round. The eye-space, broader than long, extends to nearly one-half the total length ; it is slightly narrower at the rear than at the front. The eyes are all ringed with wide black margins. The small eyes of the median row are about midway between the rear and the front side eyes. The clypeus is one-third as wide as the diameter of the front median. The front row is recurved, the side eyes being slightly separated from the median which are close together.

The mandibles are perpendicular, convex on their outer side. At a short distance from their insertion below the clypeus they begin to widen out towards the anterior end, where they are twice their width at the base. The total thickness at the anterior end, in addition to the space between the inner and outer margins of the falx-sheath, comprises a superimposed raised area reaching from near the outer margin to the corner farthest away from the base of the fang, where it ends in a large prominence. Between this and the normal falx-sheath margin it is hollowed out. On this secondary outer margin is a small fringe. The usual falx-sheath is wide and deep, the inner margin terminating in a large conical tooth at its lower end, from here to the base of the falx the thickness is considerable.

The lip is longer than broad ; rounded anteriorly and narrowed at the base for about one-fourth of its length, it is remarkably convex, the middle being a considerable height above the level of the margins. The maxillæ are upright, rounded anteriorly, narrowed at the base, about twice as long as the lip, and as broad as the latter is long. They are also very convex, being raised to the middle of their area in successively smaller layers, and terminating at their greatest convexity in a small boss.

The sternum is ovate, truncate anteriorly, where it is wider than the lip ; the front coxæ are clearly longer than the others.

The abdomen is ovate, with rather long terminal spinnerets.

There are two spines above on femora i. and ii. One weak spine on the inside of each patella, one pair at the base of tibia i., two single on the outer side, and a row of eleven on the anterior half of the inner side of the same. Four pairs under tibia ii., one pair and an anterior bunch on metatarsus ii.

The tibial apophysis of the palp is broad at the base but tapers to a fine point. The distal joint is short and broad near the base, rounded at the sides and square at the anterior end, with a short stigma springing from a hollow above the bulb. The patella is as long as the tibia.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	4½	3 in front. 3½
Abdomen.........	4½	2½
Mandibles	2½	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	4½	5	4½	=	15½
	2.	1	3½	3½	3	=	11
	3	1	3½	3½	4	=	12
	4.	1¼	4	4	4½	=	13¾
Palpi		½	2	1½	1½	=	5½

The legs are of about the same proportion as those of *T. scalaris* Thor. from Ternate. The species resembles *T. trabifera* Thor. and some others in the row of 11 spines on the side of tibia i. (Thorell, Ragni Austro-Mal. 1881, pp. 477 & 480), but differs from all in the extreme convexity of the lip and maxillæ, and the shape of the mandibles.

Group SAITEÆ.

Genus JOTUS Koch.

Jotus L. Koch, Die Arach. Austr. 1881, p. 1243.

JOTUS IGNEUS, sp. n. (Text-fig. 5.)

1 male, 1 female. (*Types of the species.*)

Female. The cephalothorax is pale red-brown, moderately thickly covered with recumbent yellowish-white hair and on the eye-space with upright white bristles; round the margin of the front eyes are fillets of curly white bristles and much longer ones of the same colour on the clypeus.

The mandibles are yellow-brown, darkest on the anterior margins, with the fangs brown at the base and pale red at the anterior half.

The lip and maxillæ are orange with dark yellow fringes, the sternum and coxæ paler yellow with yellowish-grey hair. The legs are bright yellow, the front pair being rather the darkest.

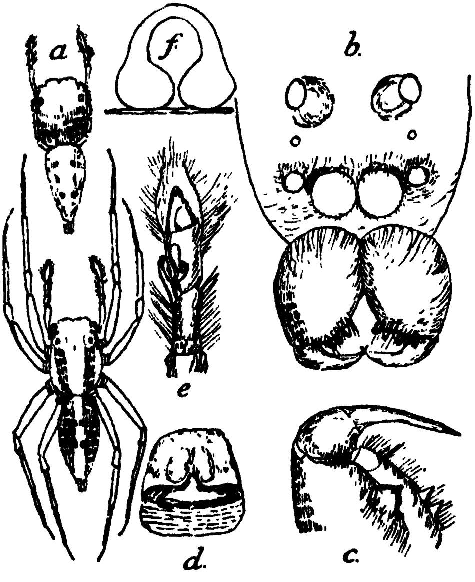
The abdomen above is pale yellow, with smooth silky white hair. Along each side a row of large brown spots forms a broken line nearly continuous at the rear end: on the under side is a wedge-shaped brown area extending from the genital fold to just above the spinnerets. The front and sides are the same colour as the upper side. The spinnerets and basal portion of the epigyne are darker yellow.

The front row of eyes is recurved, slightly wider than the rear row, which is narrower than the cephalothorax at that part, and the small median are midway between the rear eyes and the front laterals.

The single flat triangular tooth, about the middle of the inner falx-sheath margin, is particularly large, and the anterior tooth of the outer margin is also rather large.

There is a row of three short spines in front of each femur above, with two single spines about the middle. On the under side of tibia i. and ii. are three pairs of long powerful spines and two smaller spines on the inner side; on metatarsus i. and ii. underneath are two pairs of long spines; on metatarsus iii. and iv. are a pair near the base and a bunch at the anterior end, and on tibia of same two above, two on the side, and a pair underneath. On the femoral joint of the palp are two spines, on the patella one on each side, on the tibia one above, and on the distal joint one below.

Text-figure 5.



Jotus igneus, sp. n., ♂.

a., female; *b.*, eyes and mandibles of female; *c.*, mandible showing teeth of male; *d.*, epigyne of female; *e.*, male palp; *f.*, *Plexippus paykulli*, epigyne of female.

Male. Similarly coloured to the female, the sides of the cephalothorax being, however, darker brown and the brown stripes on the abdomen continuous; the brown area on the under side also begins quite at the base. On. the front pair of legs the femora are darker than on those of the others. The distal end of the tibiæ and metatarsi are also rather darker.

The male palp is of the same pattern as that of *J. auripes* L. Koch, but the epiphysis is not serrated, nor are the bristly hairs nearly so thick and long. The pattern of the cephalothorax differs in having pale median and marginal stripes, with a darker yellow-brown area between, instead of black, and the median area on the upper side of the abdomen pale instead of dark. Its larger size also distinguishes it from the former.

It will be seen from the measurements below that in the male the first pair of legs is longest, while in the female it is the fourth pair. There is no appreciable difference in the length of the tibia and patella iii. and iv. in the female, while in the male those joints in the fourth pair are only very slightly longer.

The measurements (in millimetres) are as follows:—

	Male.		*Female.*	
	Long.	Broad.	Long.	Broad.
Cephalothorax...	4½	3 in front. 3¼	4½	3 in front. 3½
Abdomen..... ...	6	2½	5	2½
Mandibles	2¼		1½	

Male.

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	4	5	4	=	14½
	2.	1	3½	4	3	=	11½
	3.	1	4	3½	3½	=	12
	4.	1	4	3¾	3½	=	12¼
Palpi		½	2	1½	1¼	=	5¼

Female.

Legs	1.	1½	4	4	3	=	12½
	2.	1¼	4	3	2½	=	10¾
	3.	1¼	4	3¾	3¾	=	12¾
	4.	1¼	4	3¾	3¾	=	12¾
Palpi		½	1½	1¼	1¼	=	4½

Group PLEXIPPEÆ.

Genus PLEXIPPUS C. Koch.

Plexippus C. Koch, Ueb. Ar. Syst. v. 1850, p. 51. (Ad part. *P. ligo*=*P. paykullii* Aud.)

PLEXIPPUS PAYKULLII Aud. (Text-fig. 5, *f.*)

Attus paykullii Aud. in Sav. Desc. de l'Égypte, 2e Edit. 1827, vol. xxii. p. 172; *l. c.* pl. vii. fig. 22, folio. ?1826.

Salticus culicivorus C. L. Doleschall, Tweede Bijd. Arach. van den Ind. Archip. p. 14, pl. ix. fig. 5: Act. Soc. Sci. Indo-Néerl. vol. v. 1858–9.

Menemerus culicivorus T. Thorell, Ragni Selebes, 1877, p. 228; id., Ragni Amboina, 1878, p. 237; id., Ragni Austro-Mal. 1881, p. 508.

Menemerus paykulli Keyserling, Die Arach. Aust. 1883, p. 1425, pl. cxxiii. fig. 4.

Plexippus paykulli T. Thorell, Ragni Indo-Mal. 1891-2, p. 369.

1 male and 3 females.

Collected from Spain and Africa; also, according to various authorities, round the world eastwards and, according to F. O. P. Cambridge, in S. America.

It is impossible to compare Doleschall's drawing of *S. culicivorus* with a recognised female specimen of *P. paykulli* without feeling that it must have been drawn from the same, and Thorell apparently arrived at this conclusion (Ragni Indo-Mal. 1892, p. 370). In his description, which is quite short, Dr. Doleschall says that the legs are in the order 4 3 2 1, while it is certain that the second pair is the shortest.

The patella and tibia iii. are of the same length as patella and tibia iv., and the rear row of eyes in the female is slightly shorter than the first row, while in the male it is quite clearly so.

Von Keyserling gives an excellent drawing of the male and adds what he says is the epigyne of the female; the latter, however, is quite unlike those of specimens in the British Museum (Natural History), which resemble the above. (See text-fig. 5, *f*.)

Group ZENODOREÆ.

Genus ZENODORUS Peckham.

Ephippus T. Thorell, Ragni Aust.-Mal. iii. p. 643 (1881).

Zenodorus G. & E. Peckham, Proc. Nat. Hist. Soc. Wisc. vi. p. 287 (1885); E. Simon, Hist. Nat. des Ar. vol. ii. 1901, p. 656.

ZENODORUS D'URVILLII Walck.

Attus d'urvillii Walck. Hist. Nat. des Ins. Apt. i. p. 459 (1837).

Ephippus d'urvillei T. Thorell, *loc. cit.* p. 653.

Zenodorus d'urvillei G. & E. Peckham, *loc. cit.*; id., E. Simon, *loc. cit.*

1 male.

This male seems clearly to belong to this species, agreeing with Thorell's elaborate description, and showing the first pair of legs longest, though not so long in proportion as in some later described species. The mandibular tooth on the inner margin is conical and quite large if the soft basal portion is taken into consideration, and only "very minute" if you reckon the point alone, which is darker and harder. The mandibles are hollowed out in the middle of the inner side, much corrugated, and the stout base of the short curved fang occupies the whole of the anterior end of the falx.

A raised flat rim at the front of the clypeus seems a feature in this genus *Zenodorus*; it is not quite so well defined in the female as in the male.

The measurements (in millimetres) are as follows :—

	Long.	Broad.
Cephalothorax...	4	2½ in front. 3½
Abdomen.........	5	2½
Mandibles	2	

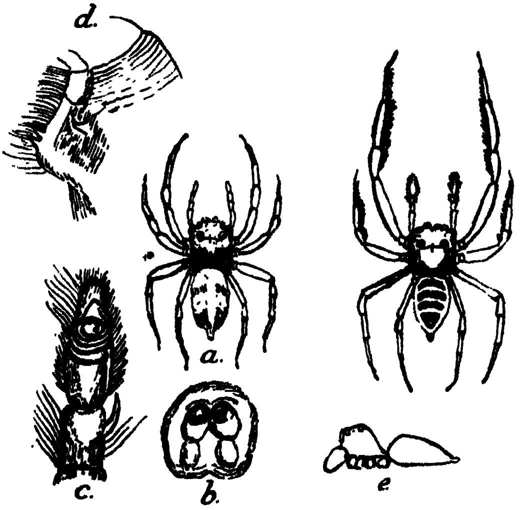
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	4	2, 3½	2½, 1	=	14½
	2.	1¼	3	2½	2¼	=	9
	3.	1	4	1, 2½	2¼, ¾	=	11½
	4.	1¼	3	¾, 2¼	2, 1	=	10¼
Palpi		½	2	1	1½	=	5

Zenodorus danae, sp. n. (Text-fig. 6.)

8 males and 10 females. (*Including the types of the species.*)

Female. Cephalothorax black-brown, with very brilliant green, red, and yellow iridescent scales at the sides and rear of the eye-space, with a few scattered here and there between the eyes and on the clypeus. The mandibles, lip, and maxillæ are dark red-brown with brown bristles and upright, flat, club-shaped, pearly-white iridescent hairs. The sternum, though dark, is more yellow-brown, with pale grey hair.

Text-figure 6.



Zenodorus danae, sp. n., ♂.

a., female; *b.*, epigyne; *c.*, male palp; *d.*, mandible showing teeth; *e.*, profile.

The legs and palpi are bright orange-yellow, with brown spines and bristles. The two rear pairs of legs darken into yellow-brown on the upper surface of the tibial and metatarsal joints. The abdomen is black-brown on the upper side; on the basal area, along the sides of the rear half, and in a procurved fillet across the middle, is a pattern formed of the green, red, and golden scales.

The under side is pale yellow-brown without any pattern.

The eye-space is two-fifths of the total length of the cephalothorax; the rear row is as broad as the front row, which is recurved; the cephalothorax at the rear row of eyes, its broadest part, considerably exceeds them in breadth. The clypeus is less than one-half the diameter of the front median eyes and terminates in a thick flat marginal rim. The mandibles are short, stout, and conical, the fang very thick at the base; on the inner margin of the falx-sheath the chitinous rim is continued only a short way down as far as a conical tooth; this, though rather small, is not "very minute," and below it the side is hollowed away. On the outer margin are two points on a single base and a thick fringe of bristles. The lip is as broad as long, rounded anteriorly, half the height of the maxillæ, which are upright, convex, broad, and rounded on the outer side. The first pair of coxæ, slightly wider apart than the breadth of the lip, are longer than any of the others.

The abdomen is oval, about twice as long as broad.

There are two pairs of stout spines on the under side of metatarsus i. and similar smaller ones under metatarsus ii.

Three pairs of spines under tibia i. with two single spines on the inner side. One on each patella. On femora iii. and iv. there are 1, 1 spines above, and numerous spines on the tibiæ and metatarsi.

On the inner side of the patella, tibia, and metatarsus i. there is a thick fringe of bristles.

The front pair of legs are stouter than the others.

The vulva consists of two broad oval depressions side by side, separated by a narrow ridge with two other shallower and smaller foveæ below the first pair, the whole on an elevated, rather square area.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	5	3 in front. 4
Abdomen.........	6	3½
Mandibles	2	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1¼	4	4	3	=	12¼
	2.	1	3½	3	2½	=	10
	3.	1	4	4	3½	=	12½
	4.	1	3½	3	3½	=	11
Palpi		½	1¾	1½	1¼	=	5.

This species would seem to be rather close to *Z. julia* Thor. (l. c. p. 650), which it resembles apparently in the pattern of brilliant scales on a black ground and the form of the epigyne, but differs from it in the much more even lengths of the legs, the third pair in *Z. julia* exceeding the first and fourth by 2½ and 3½ millimetres respectively, and being also darker in colouring.

It is much paler in colour, larger, and the legs i. and iii. are nearer the same length, than in Mr. Pocock's *Z. variatus* (Willey, New Britain, etc., vol. i. 1899, p. 117). It differs also from *Z. d'urvillei* (Walck.) in the much brighter colouring and absence of rings on the legs, while the pattern of the epigyne differs from that drawn by Von Keyserling (Die Arach. Aust. pl. cxx. fig. 4 *d*).

Males. In most respects these agree so closely with the females described above and are represented by so nearly the same number of specimens in the present collection, that it is difficult to avoid the conclusion that they are males of the same species. The chief difference is that the front pair of legs are much longer than the others, a fact which does away with one of the characteristics of the genus, in which the third pair of legs are said to be much longer than the others. Were it not, however, for the special enlargement of the first pair, the third would be the longest.

The clypeus is not quite so broad as the diameter of the front median eyes, the rear row is as broad as the front row. The eye-space slopes forward, and from the hinder row the thoracic part slopes steeply to the rear margin.

The mandibles are flatter than in the female, both the outer and inner sides being strongly corrugated transversely. The tooth on the upper margin is of moderate size; the inner margin of the falx-sheath is cut away to about one-third of the length of the outer margin and exists only for a short distance near the base. The lip is as broad as long, rounded in front, hollowed out on either side of the base, and transversely corrugated. The sternum is three-fourths as wide as it is long, truncated in front, and the coxæ are as far apart as the greatest width of the lip. The male palp has a flagellum in about three spirals at the anterior end of a plain oval bulb.

The front pair of legs is strongly fimbriated on the under side of the patellar, tibial, and metatarsal joints. The cephalothorax and abdomen are black-brown, with a pattern of opalescent pearly scales.

Under metatarsus i. are two pairs of stout spines, but none at the side. Three pairs under tibia i. One spine each on patellæ iii. and iv., and a bunch at the anterior end of metatarsi iii. and iv.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	5	3½ in front. 5
Abdomen.........	6	3½
Mandibles	3	

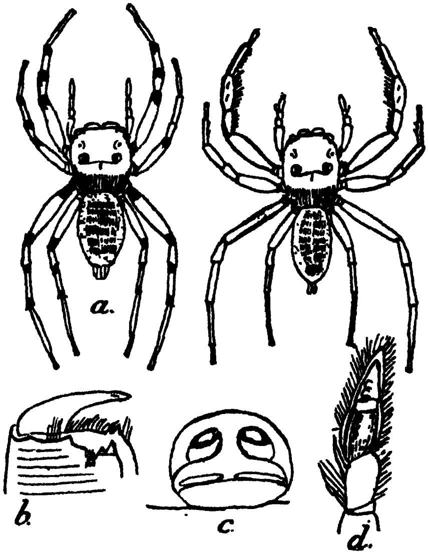
		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	2½	7	2½, 5½	3½, 1½	=	22½
	2.	1¾	4	4	3½	=	13¼
	3.	1½	5	2, 2½	3½, 1	=	15½
	4.	1½	4	4	4	=	13½
Palpi		3/1	2	1½	1½	=	5¾

ZENODORUS RHODOPE, sp. n. (Text-fig. 7.)

2 males and 2 females. (*Including the types of the species.*)
Males with one tooth on inner margin of falx-sheath.
Females with two teeth on inner margin of falx-sheath.

Female. The cephalothorax is dark yellow-brown on the cephalic part; all the eyes on large black tubercles. Small white lancet-shaped scales and upright brown bristles spread at

Text-figure 7.



Zenodorus rhodope, sp. n., ♂.
a., female; *b.*, mandible showing teeth; *c.*, epigyne; *d.*, male palp.

intervals about the eye-space. The thoracic part is nearly black-brown to the sides of the posterior margin. On the clypeus are long white upstanding bristles.

The mandibles are dark red-brown, with a paler patch at the lower inner margin of the falx. The fangs red-brown. The lip and maxillæ dark brown, yellow-brown at the margin with yellowish-brown fringes. The sternum is yellow-brown. The coxæ bright yellow. Legs and palpi as described for *Z. syrinx.*

The abdomen on the upper side is dark greyish-brown, covered round the sides and base thickly, in the central area more sparsely, with pearly-white squamules and upstanding brown normal hairs. On the under side it is much more thickly covered with short, upstanding, white bristly hair; the spinnerets are the same; the epigyne dark yellow.

Arrangement of spines on the legs:—

I. Femur: 1 1 1 above and 1 1 1 small at anterior end.
Patella: 1 on inner side and long bristle.
Tibia: 3 pairs underneath.
Metatarsus: 2 pairs very long and stout on under side.
II. Femur: 1 1 above and 1 1 1 at anterior end on inner side, 1 1 on outer.
Patella: 1 and bristle.
Tibia: 1 at side. 2 fine pairs underneath.
Metatarsus: 2 pairs much more powerful.
III. Femur: 1 1 and 1 1 1.
Patella: 1.
Tibia: 1 on inner side and pair at anterior end.
Metatarsus: 2 pairs and bunch at anterior end.
IV. Femur: 1 on outer side, 1 in middle, 1 at anterior end.
Patella: 1 on inner side and bristle at anterior end.
Tibia: 1 1 on inner side and pair at anterior end.
Metatarsus: 1 1 on inner side and thick bunch at anterior end.
Palp: 1 1 on femur above.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	4½	3½ in front. 4
Abdomen.........	5	3
Mandibles	2	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	4	3½	3	=	12
	2.	1¼	3	3	2½	=	9¾
	3.	1¼	5	4	4½	=	14¾
	4.	1¼	4	3	4	=	12¼
Palpi..............		1	1½	1¼	1¼	=	5

The females are rather more highly coloured than the males and the legs more distinctly ringed, but so closely resemble them in structure and general coloration that I have supposed them to be of the same species, though unless captured together the matter is always open to doubt.

In the males the tooth on the inner falx-sheath is raised above the lower end of a straight base, which in the females has a point at the other end also, enough to make it really fissidentated; but these two and the following *Z. syrinx* with no teeth at all are all so much alike, and so distinctly resemble *Zenodorus d'urvillei*, the type species, that I am unable to separate them from that genus.

ZENODORUS SYRINX, sp. n. (Text-fig. 8.)

1 male and 1 female. (*Types of the species.*)

Male without teeth on falx-sheath.

Female without teeth on inner margin of falx-sheath.

Male. Cephalothorax black-brown on the eye-space, bright red-brown just behind the same, behind this again dark brown to the rear margin; scattered over this at intervals are lanceolate pearly scales, more thickly at the sides and on the clypeus, where some of them are lengthened into flat bristles. On the front margin of the clypeus is a flat raised rim. The mandibles are black-brown with transverse corrugations of green opalescence, and, except for a few flat bristles at the inner edge of the base, quite bare.

The base of the falx is as thick through as it is broad transversely, but tapers towards the anterior end. A transverse section at the base would be almost square. The median part of the inner margin is hollowed out, thus leaving an oval opening between the two falces.

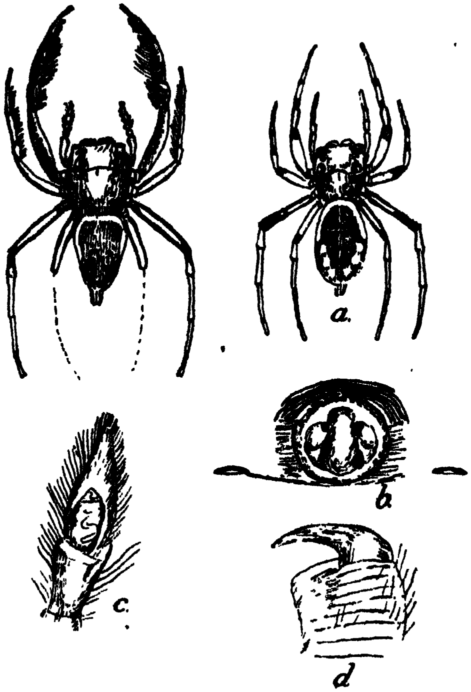
In the specimen before me there is no tooth on the lower margin of the falx-sheath, and none visible in the thick fringe on the outer.

The lip and maxillæ are nearly black-brown, with a narrow yellow-brown edging and dark grey fringes. The sternum and coxæ are dark orange-yellow, with fine upstanding yellow-brown hair.

The femur and patella of the front pair of legs are dark orange; the tibia and metatarsus black-brown with a thick black fringe of long bristles on the under side, those on the metatarsus being the shorter. The tarsi quite pale yellow. The metatarsus of the second pair is pale, otherwise the same colour as the first; the third and fourth pairs are paler yellow-brown.

The abdomen on the upper side is dark greyish-brown, with short upstanding brown hair over the basal area; following this is a broad field of pearly-grey scales, and along the sides patches of the same as far as the spinnerets; the under side is pale yellowish-grey.

Text-figure 8.



Zenodorus syrinx, sp. n., ♂.

a., female; *b.*, epigyne; *c.*, male palp; *d.*, mandible.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	5	3 in front. 3½
Abdomen.........	2	2½
Mandibles	2	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	4½	5	3	=	14
	2.	1	3	3	2½	=	9½
	3.	1	5½	4½	5	=	16
	4.	1	4				

Female. Cephalothorax dark yellow-brown; all the eyes on large black tubercles. Long brown bristles and short white lancet-shaped scales spread here and there. The mandibles black-brown with red-brown fangs and brown fringe. A paler patch just below the lower corner of the falx-sheath. The lip and maxillæ are dark yellow-brown with paler edgings. The sternum pale yellow-brown, with upstanding brown bristles and pale yellow-grey hair. The coxæ bright yellow. The whole of the palp the same, with upstanding yellowish-grey bristles. The basal half of the femora of all the legs is bright yellow-brown, the anterior half brown; patella and tibia yellow-brown, metatarsus and tarsus orange-yellow.

The abdomen is black, with a fillet of white squamous hairs round the base reaching along each side to half the length of the abdomen. From the end of this on each side are three large white spots continuing the line to the spinnerets; on the under side it is plain greyish-yellow; the hairs all ordinary, very fine, pale yellow. The spinnerets rather long, conical, and darker brown, on a white chitinous base half their length, have long straight brown hair and a short cylindrical second joint.

The inner margin of the falx-sheath is cut away and hollowed out to the outer margin, at the lower end of which are two moderate-sized teeth. The inner side of the falx-sheath itself is also hollowed out, most deeply about the middle.

The lip is as broad as long, truncate and slightly hollowed anteriorly, half the length of the maxillæ, which are convex, upright, rounded anteriorly. The front coxæ are farther apart than the lower margin of the lip is wide. The sternum ovate, truncate, and narrowest in front, is flat at the anterior end for one-third of its length and thence to the posterior end convex.

The epigyne consists of two oval hollows resting against the upper part of a broad longitudinal convex septum; below these hollows and fitting into the lower part of the same central septum are two chitinous triangular cushions. The whole inside an oval frame.

Arrangement of spines on the legs:—

On femur i. & ii. above are single spines 1 1, and a row of three small on the inner side at the anterior end.

On patella i. & ii. a short spine on the inner side and a very long bristle at the anterior end.

On tibia i. & ii. three pairs on the under side.

On metatarsus i. & ii. two pairs (very stout) on the under side.

On patella iii. & iv. one small on inner side and a very long bristle at distal end.

On tibia iii. & iv. one small pair below at the anterior end, and two single on inner side.

On metatarsus iii. & iv. one small underneath about the middle, and bunch at anterior end.

On metatarsus iii. two single at the side, but none on iv.

The measurements (in millimetres) are as follows :-

Cephalothorax...	3	3 in front. 3½ 4 high.
Abdomen.........	5½	3½
Mandibles	2	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1¼	3¼	3¼	2½	=	10¼
	2.	1	2½	2½	2	=	8
	3.	1	4½	3¾	3½	=	12¾
	4.	1	3¼	3	3½	=	10¾
Palpi		¾	1½	1½	1¼	=	5

This species differs from *Z. rhodope* in having no teeth on the falx-sheath margin, in not having the legs ringed, slight differences in the male palp and epigyne of the female, and in the spines as detailed, but otherwise the two species closely resemble one another.

Group THYENEÆ.

Genus MOPSUS Karsch.

Mopsus Karsch, Mittheil. Münchener Entom. Vereins, vol. ii. 1878, p. 31.

MOPSUS MORMON Karsch.

Mopsus mormon Karsch, *loc. cit.*; T. Thorell, Ragni Austro-Malesi, p. 462 (1881).

Ascyltus penicillatus Keyserling, Die Arach. Aust. p. 1319, pl. cxii. (1882).

Mopsus mormon Keyserling, *loc. cit.* p. 1475 (1883).

1 male and 2 females.

Previously recorded from New Guinea, Cape York, Bowen, Rockhampton, and Sydney.

Group PLEXIPPEÆ.

Genus BATHIPPUS Thor.

Bathippus Thorell, Ragni Indo-Malesi, pt. iv. vol. ii., 1891-2, p. 401; E. Simon, Hist. Nat. des Ar. vol. ii. 1903, p. 740.

BATHIPPUS MONTROUZIERI, var. PAPUANUS Thor.

Plexippus montrouzieri Lucas, Revue et Mag. de Zool. 1869, p. 209, pl. xi. figs. 8-12; Thorell, Ragni Austro-Malesi, iii. 1881, p. 526.

6 males.

Previously recorded from Wokan, Aru Islands, and Fly River, New Guinea.

Section **Fissidentati.**

Group HASARIEÆ.

Genus HASARIUS Simon.

Hasarius E. Simon, Hist. Nat. des Ar. vol. ii. 1903, p. 795.

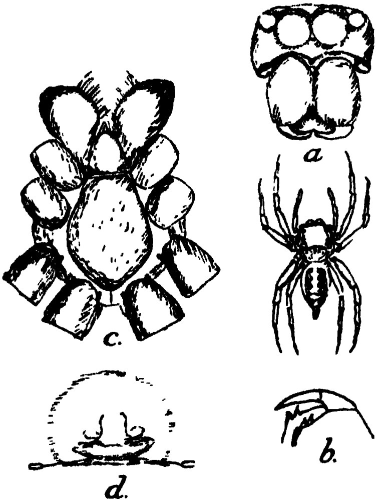
HASARIUS GLAUCUS, sp. n. (Text-fig. 9.)

1 female. (*Type of the species.*)

Female. The cephalothorax is orange-yellow, black between the side eyes; mandibles, lip, maxillæ, sternum, and legs all pale yellow, with nearly white hairs and grey spines.

The abdomen above is dark grey at the sides with short recumbent white hairs, a broad pale area at the base, and a pale yellow-grey scolloped longitudinal stripe down the middle. On the under side the median area is the darker, the sides being pale yellow-grey. The spinnerets are yellow, springing from a long white chitinous base nearly as long as themselves. The epigyne is rather dark yellow.

Text-figure 9.



Hasarius glaucus, sp. n., ♀.

a., front eyes and mandibles; b., mandibular teeth and fang; c., lip, maxillæ, sternum, and coxæ; d., epigyne.

The eye-space is spread over two-thirds of the cephalothorax. The lip is longer than broad. Sternum ovate, truncate, and narrowest in front; the third coxa is isolated from the second and fourth.

On the under side of tibia i. are two pairs of long spines, one pair of short ones at the anterior end, and two single spines on the outer side; underneath the metatarsus there are three pairs (two very long) and a bunch at the anterior end.

Two single spines above and two pairs on metatarsus iii. and iv.; under tibia iii. and iv., a pair of fine spines in the middle and another at the anterior end.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	2½	2 in front. 2
Abdomen.........	3	2
Mandibles	1	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	½	2	2¼	1½	=	6¼
	2.	½	2	2	1¼	=	5¾
	3.	¾	2½	2½	2	=	7¾
	4.	½	2¼	2	2	=	6¾
Palpi		¼	1¼	1	¾	=	3¼

Differs from *H. coprea* Thor. (Rag. Indo-Mal. pt. iv. vol. ii. 1892, p. 434), which it somewhat resembles in having a longitudinal pale median stripe on the abdomen instead of transverse black streaks, and the hind pair of legs clearly longer than the first instead of equal.

Group CYTÆEÆ.

Genus CYTÆA Keys.

Cytæa Keyserling, Die Arach. Aust. 1882, p. 1380; E. Simon, Hist. Nat. des Ar. vol. ii. p. 816.

CYTÆA SYLVIA, sp. n. (Text-fig. 10.)

1 female. (*Type of the species.*)

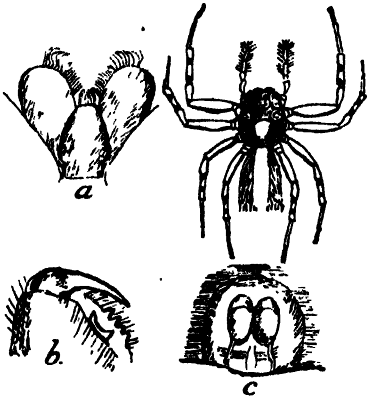
Female. Cephalothorax dark red-brown, black between the side eyes. White and coloured scales on the cephalic part. On a lighter red ground behind the eye-space is a large patch of white squamules reaching to the rear margin; on the clypeus is a bush of long white bristles; the mandibles are dark brown on the inner margin, pale chestnut-red on the outer sides and brown underneath. The fangs red, paler at the points. The lip and maxillæ are brown on the lower and middle parts, yellow over a rather wide area in front. The sternum and coxæ are pale yellow with white upstanding hair. The two front pairs of legs have the femora pale red-brown on the upper side with a dark brown patch at the anterior end, and dark brown on the under side, thickly covered with white squamules on the pale portions, and with coloured squamules on the darker parts. The patella and tibia are pale and dark brown in alternate rings; the metatarsus and tarsus pale yellow-brown; the two posterior pairs of legs are somewhat paler, but with similar brown rings and squamules intermixed with upstanding brown bristles. The palpi are yellow-brown, with thick brushes of long white bristles.

The ground-colour of the abdomen is pale yellow, covered with thick masses of white, black, and red lancet-shaped scales all mixed up together.

The eye-space and thoracic part each occupies about one-half of the total length of the cephalothorax, but, the upper flat part continuing for about halfway on the thoracic, the rear slope is quite steep at the end.

The front row of eyes is straight along the upper edges, the rear eyes about the same diameter as the front lateral. The second row of eyes halfway between these two are quite small; the clypeus about one-fourth the diameter of the front median eyes.

Text-figure 10.



Cytæa sylvia, sp. n., ♀.

a., lip and maxillæ; *b.*, mandibular teeth and fang; *c.*, epigyne.

The mandibles are convex on the outer side. The fissidental tooth is rather high and its own length distant from the base of the fang, its lower corner forms the larger of two conical teeth; on the outer margin are four teeth, the two upper being largest and the lower quite small.

The lip is clearly longer than broad, narrowed and rounded in front, and more than half the length of the maxillæ. The front coxæ are barely separated by the distance of the breadth of the base of the lip, so that the sternum is narrower in front than at the posterior end; it is ovate, convex over the posterior two-thirds, with a broad flat margin between it and the coxæ. The abdomen is oval, but is partially destroyed. The epigyne consists of a pair of deep oval depressions upright, side by side, separated by a black chitinous ridge widest in the middle, which runs round the upper and lower edges and inner side; the upper part of each of these depressions is covered over with a light sort of deck, dark streaks run down from their lower ends to the genital fold, and the whole stands on a raised area arched anteriorly.

In the middle of the upper side of each femur is a single spine and a row of four abreast at the anterior end; on each patella one spine each side; under all the metatarsi are three pairs of spines, on the inner side two single and on the upper side a pair near the base followed by a single. Under metatarsus i. and ii. two pairs of very long spines, and two single on the inner side; on metatarsus iii. two bunches of spines; on metatarsus iv. one pair underneath, one above, two at the side, and a bunch at the anterior end.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	4	2 in front. 3
Abdomen.........	—	2½
Mandibles	1½	

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1¼	3¼	4	3	=	11½
	2.	1	3¼	2¾	2	=	9
	3.	1	2½	3	2½	=	9
	4.	1¼	2½	2½	3	=	9¼
Palpi		½	1¼	1¼	1	=	4

In the structure of the mouth-parts, proportion of legs, and pattern of epigyne, this rather closely resembles *C. alburna* Keys. It is at least a third larger, and is easily distinguished by the prominent white streak on the cephalothorax and the bright coloration of the scales on the abdomen.

CYTÆA LAODAMIA, sp. n. (Text-fig. 11.)

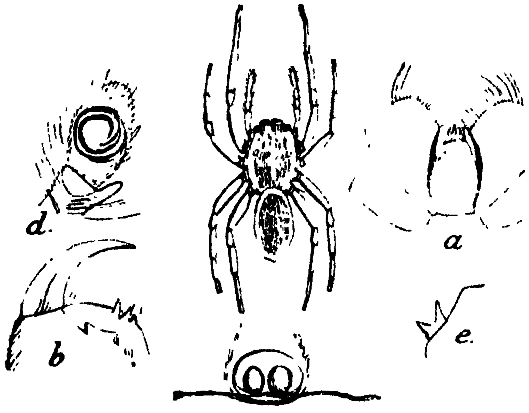
1 male and 2 females. (*Including the types of the species.*)

Female. Cephalothorax black-brown with greyish-white squamules and brown bristles, reddish bristles between the front eyes, and thick long white bristles on the clypeus. Mandibles black-brown with red-brown fangs. Lip, maxillæ, sternum, and coxæ dark brown, the fringes on the former brown and short upstanding greyish-white hair on the remainder. The abdomen on the upper side is brown over the median area, with a white fillet of squamous hairs at the base and down each side as far as the spinnerets; the brown area has also white squamules in patches mingled with brown, and a more or less distinct median line of the same running down the anterior half; on the under side it is brown at the sides and yellow-grey in the central area with the same pale squamules. The femora, patellæ, and tibiæ of the legs are brown thickly covered with greyish squamules: the metatarsi are dark brown at the base and in front, with a yellow ring in the middle, and the tarsi yellow. The palpi are likewise brown, with white squamules on the upper surface, and long white bristly fringes on the sides of the patellar, tibial, and distal joints, smooth underneath.

The epigyne is greenish-grey in the central area, pale brown round the sides.

The spinnerets are pale brown, and spring from a conjoined chitinous base as high as one half of their length. The bifid tooth on the inner falx-sheath stands out high, hollowed in the centre, the two ends form large flat conical teeth. There are three medium-sized teeth on the outer margin. The lip is convex, rounded anteriorly, but is hollowed out from nearly halfway down to the lower corners: this part being continuous with the rest, leaves it as wide at the base as it is high—it is rather more than half the length of the maxillæ. The sternum is oval, and while it narrows to the width of the convex portion of the lip, the front coxæ are as far apart as the full distance between the next pair.

Text-figure 11.



Cytæa laodamia, sp. n., ♀.

a., lip and maxillæ; *b.*, mandibular teeth and fang of male; *c.*, epigyne; *d.*, male palp; *e.*, inner mandibular teeth of female.

Male. Similarly coloured to the female, but the upper side of the patellar and tibial joints are paler red-brown, and the fringe on the under side of the palpal distal joint darker brown.

The bifid mandibular tooth on the inner margin is longer than in the previously described species, less distinctly shaped at the corners, and slightly serrated in the middle.

The measurements (in millimetres) are as follows :—

	Female.		*Male.*	
	Long.	Broad.	Long.	Broad.
Cephalothorax...	4	2½ in front. 3	3¾	3 in front. 3½
Abdomen.........	4½	2½	4½	2¼
Mandibles	1½		2	

Female.

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	3	3½	3	=	11
	2.	1	3	2½	2	=	8½
	3.	1	3	3	2½	=	9½
	4.	1¼	3	3	2½	=	9¾
Palpi		½	1½	1¼	1¼	=	4½

Male.

		Coxa.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1¾	4	5	4	=	14¾
	2.	1¼	3	3½	2½	=	10¼
	3.	1¼	3	3	2¼	=	9½
	4.	1¼	3	3	2½	=	9¾
Palpi		⅓	2	1⅓	1¼	=	5¼

This, although a good deal larger than either von Keyserling's or Prof. Kulczynski's species, agrees in shape and the arrangement of the spines with the definition of the genus as amplified by M. Simon.

It will be seen that pat. + tib. iii. and iv. are of equal length, in which it differs from *C. alburna* Keys. as well as in the pattern of the epigyne and general coloration.

The form of the epigyne is the same as that given by Prof. Kulczynski for his *C. subsiliens*, and, as in that species, the eye-area, although considerably broader than long, is still longer than the pars thoracica. It differs from the latter in the third and fourth pairs of legs being shorter than the first, instead of longer.

EXHIBITIONS AND NOTICES.

May 11, 1915.

Dr. A. Smith Woodward, F.R.S., Vice-President, in the Chair.

The **Secretary** read the following report on the Additions to the Society's Menagerie during the month of April 1915:—

The number of registered additions to the Society's Menagerie during the month of April was 230. Of these 150 were acquired by presentation, 25 by purchase, 38 were received on deposit, 6 in exchange, and 11 were born in the Gardens.

The number of departures during the same period, by death and removals, was 115.

Amongst the additions special attention may be directed to:—

1 Goeldi's Marmoset (*Callimico goeldii*), from Bunda River, Bolivia, new to the Collection, deposited on April 14th.

1 Houbara Bustard (*Houbara undulata*), from North Africa, received on deposit on April 27th.

A valuable Collection of Waterfowl containing sixty-eight individuals representing twenty-five species, presented by Alexander L. Duncan, F.Z.S., on April 23rd.

The House-Fly Exhibition.

Prof. H. Maxwell Lefroy, M.A., F.Z.S., Curator of Insects, exhibited specimens of various kinds of fly-traps and made the following remarks upon the House-Fly Exhibition:—

"A small exhibition of Flies and methods of dealing with them will be open on Wednesday, May 12th, and continue open while it is of use and interest. There will not necessarily be anything original in the exhibition, and it was planned at first simply to show the American fly-traps, which are not used in this country and which are likely to be valuable. From this it has grown to include all the information about flies that a health-officer might require, and we are endeavouring to arrange it so that such an officer can obtain in a short time the technical information about flies that is available, without himself having to hunt up the literature. We have also tried to make it useful by getting samples and prices of the necessary chemicals etc., by having copies of books and other literature, and by condensing into a short illustrated pamphlet authoritative information.

Since this was planned the Press have taken it up, somewhat to our embarrassment, and we have had to make it as interesting and instructive as we can for the general public: so we are enlarging the scope, providing tabloid information and posters, and generally trying to rub in the essential facts.

Flies are likely to be important this year for several reasons the first is that with a shortage of labour scavenging will not be so well done; manure cannot be so quickly disposed of, and there will be local outbreaks of flies if the weather conditions are suitable.

The usual vigilance exercised in inspection, and in destroying material capable of breeding flies will be impossible this year; there will be accumulations of manure and refuse in towns, on farms, on market gardens and where cavalry are quartered, and this will provide breeding-material particularly for house-flies.

The second reason is that in areas affected by the war, flies are increasing, because sanitation and the disposal of fly-breeding material will not be possible, and this will accumulate to an unusual extent. I have evidence of this already from the Continent: these flies will not come over here, but they will lead to a greater spread there of the diseases that they carry and we shall be affected; if cholera breaks out in Serbia, Austria, or other parts of South Europe, it may spread in fly-invested areas and get widely diffused. I do not want to be an alarmist, but I think we must be prepared for such possibilities when a war of this magnitude is in progress.

If flies are going to be unusually numerous so will the diseases they carry, and one of these is typhoid: we inoculate the men who go to the front, but we here are not inoculated.

The third consideration is that there is a likelihood of a very terrible plague of flies actually where the fighting is in progress, which will very deeply impress those who are there: no one quite knows where the fighting-line will be, but wherever it is the flies are likely to be a feature. This is a good time, then, to do what we can to rub the facts in, to get them known, to arouse interest, and to help those whose business it will be to fight flies: already we have been visited by Army Doctors anxious to get quickly all the facts about flies, and this will become increasingly useful.

For these reasons we have made all we can of this little exhibition, and, though it is not nearly complete, it contains useful information and will be open at once.

It is not necessary for me to go into the details of the life-history and habits of flies to-night: you can see it all in the exhibition to-morrow, and you are probably all aware of the main facts. We are showing the various stages of the House-fly and the Blow-fly, the common flies of houses, where they breed, what they feed on, the diseases they carry, how they carry them, and so on. The facts are condensed on diagrams, posters, pictures, and the methods of fighting flies are described in a short pamphlet.

What can one do against flies? There are three lines on which one can work, adjusting one's methods to local circumstances of course:—

1. Removal or treatment of breeding-material.
2. Traps.
3. Poisons.

The materials in which house-flies lay eggs and develop are well known; they are horse-manure, excrement, rotting vegetable-matter such as vegetables, compost heaps, rubbish heaps, and the like: *manure, excrement, garbage*, and *fermenting rubbish* are the danger sources for house-flies. For blow-flies animal-matter is the chief source, even in extremely small amounts: a dead mouse, a hollow bone, a putrifying whelk, a dead sparrow, a scrap of meat, a fish-head, these will all nourish blow-fly maggots: you will be astonished when you see what a small amount is needed and what a number of blow-flies will develop from the scraps in the dust-bin.

The number of flies this year will depend very largely on the extent to which this material is removed or destroyed, not only by the authorities but by the efforts of every one concerned. Until people at large realize what a danger flies are and what it is that they breed in, we are certain to have quantities of flies: it is an unpleasant subject that people prefer to leave alone, but there may be enough flies this year to make people want to know about them.

If the breeding-material cannot be disposed of, can it be treated so that it will not breed flies? Can we treat manure without impairing its value, and can we show how to treat the manure-heap in every garden? We have the available information collected, and the original papers can be consulted; so far as is possible inquirers will be advised.

The second method is to trap, and I show to-night two American traps, with Mr. Seth-Smith's improvement, a folding-trap made in the Gardens, and two other patterns of folding-trap that are being tested. These and any improved ones will be shown, and if any are available the prices etc. stated. Some patterns are for home manufacture, some will, we hope, be available at popular prices.

We show also a trap that is meant for the household dust-bin, which will catch any flies going to the dust-bin and any that have developed in it and that seek to escape. If a dust-bin of this kind is used to contain stable-manure it will probably be a very valuable trap for house-flies generally, and the stable become a means of generally reducing flies in the neighbourhood instead of adding to them.

The third method is to poison flies, and this has yielded remarkable results abroad. There are harmless liquids for use indoors and poisons for use by skilled persons outside, particularly for hospitals and large institutions. These will be of greater interest to professional men than to the public generally: we have the original accounts of these, and it will be possible for a health officer to read quickly what has been done.

It may perhaps sound to you as if we knew all about flies, and as if we should be able to solve all the difficulties that will be brought to us—I wish, indeed, it were so. It is astonishing how little practical information there is; what there is, is largely from America—very little has been done here, and we are very far indeed from having the information we need.

We have here to-night representatives of the Press, the educators of the man in the street, and the exponents of his collective opinion. I hope Fellows of the Society will forgive me if I take the opportunity to urge the Press to emphasise to the Great British Public this fact, that *we are actually at a loss to know how to meet the fly problem here and at the front because the necessary scientific investigation has not been done.* As a nation we neglect and underrate the value of applied science; it is not the function of the Zoological Society to deal with the application of Science to national health, and it is the wide sympathies of its Council and officers that enables me to make use of its resources to deal with this problem: but there is no organised body, no department of Government that stimulates and develops the study of Applied Biology. If there had been, we could answer the questions that come in to us daily from municipal health authorities, Army Sanitary officials, and the public, as to means of dealing with flies and other vermin.

I am not talking in a general way, but I have definite specific problems that are in need of solution at once.

1. *Baits for Flies.*—The recommended baits for fly-traps are formalin, beer, vinegar, milk, alcohol, and a few others: these are things arrived at by chance. It seems likely that we might find a really good bait, something that would draw in every fly for a quarter of a mile round, if we worked systematically on the line of testing substances likely to be found in the breeding-materials that flies seek. What brings the fly to the manure heap? Smell possibly; if so, can we find a substance of not too intolerable a smell that could be used to bait a trap in a corner of the garden and that would really bring in all the flies. I think we can, but it will require investigation, and it is a bad time to start investigating when the problem is imminent: we have actually begun with the assistance of the Organic Chemistry Department of the Imperial College, and we hope to get something out, but it is work that should have been all done long ago.

2. Beside *baits* based on the fly's breeding-place, can we get a bait *based on his food*? Why do flies sometimes take formic aldehyde? Is this the best or the only one, or are there other definite substances of far greater attractiveness to flies which they associate with their food? It is worth trying, and obviously if we can get a really potent attractor it will help immensely.

3. *Baits based on Sex.*—How does the male find the female? By scent, by sight, by what?

I remember in India a planter sent me some fruit-flies with the remark that when he put a particular mosquito essence on his handkerchief these flies followed him continually; the essence contained citronella oil, and a drop of this oil will bring the males of these flies from all around: investigation showed that the female produces this oil, and it is by its scent that the males find them: we have now a method of dealing with this fly.

I quote this quite true story as an example; and it might be worth while studying the house-fly and the blow-fly from this point of view.

4. Questions are coming in about *treatment of manure-heaps* to keep flies away: is there anything deterrent to flies? It happens that we have some recent research work on this very point, but only as regards blow-flies; it is work done at the Cooper Research Laboratory at Watford. There is here an important line of work and one which is going to be of immediate importance.

5. *Treatment of Manure-heaps to kill Maggots in them.*—Some work has been done on this point in the United States and Canada, but I believe that much better methods only need to be worked out, possibly using the new vapour-poisons that have been found during the last year. In America they recommend borax, but it seems likely that better and cheaper methods will be found.

I have now shown you investigations which, if done in the past, would have enabled us to deal with this fly problem; so it is, of course, with all branches of science, but I have been able here to give you definite concrete cases and not simply glittering generalities.

I have devoted more time to this point perhaps than I ought because this particular problem will affect people closely, because the lives of children will continue to be lost till we grapple with it, and because it is not often one gets a chance of reaching the Press. Perhaps some wealthy and enlightened person will endow fly-research, perhaps some organised body will take it up, perhaps even some day the Government will think of it. I do hope that in this case the Press will put the issues clearly and definitely.

To return to the flies. We hope to open the exhibition to-morrow, and to admit the public at certain hours, the health officials, doctors and technical folk at others. We owe much to those who have helped to organise, and who have prepared or lent models, posters, pictures, traps, samples, and appliances. Dr. C. J. Martin, the Director of the Lister Institute, has very kindly revised the pamphlet as regards diseases carried by flies, and we hope to have that out this week.

In these times we all do what we can, and I am privileged to be able to utilise the facilities of the Gardens for this exhibition. It is perhaps a new departure for the Society, an unusual feature that may be looked on as unseemly by some of the Fellows. I think that the circumstances justify it, and that if it does good and anything comes of our work, the Nation will be indebted to the Society, and this incursion into practical applied entomology will not be regretted."

May 25, 1915.

Prof. E. W. MACBRIDE, D.Sc., F.R.S., Vice-President,
in the Chair.

Mr. R. I. POCOCK, F.R.S., F.Z.S., Curator of Mammals, exhibited two pieces of skin cut from the shoulder of a wild boar and a wild sow (*Sus scrofa*) to show the difference in thickness between the two, the skin of that area in the boar being about four times as thick as in the sow.

Mr. Pocock also exhibited some skins of Asiatic and African Porcupines, and pointed out the gradation that could be traced from the Bornean *Trichus* through *Atherura* to *Hystrix* in the shortening of the tail, the evolution of the rattle, the growth of the crest on the head, and the elaboration of the spine-armature. He also showed a piece of the skin of a Javan Porcupine with some of the quills cut short to illustrate their definite arrangement in short, regular transverse rows.

June 8, 1915.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

The SECRETARY read the following report on the Additions to the Society's Menagerie during the month of May, 1915:—

The number of registered additions to the Society's Menagerie during the month of May was 136. Of these 66 were acquired by presentation, 9 by purchase, 14 were received on deposit, 35 in exchange, and 12 were born in the Gardens.

The number of departures during the same period, by death and removals, was 123.

Amongst the additions special attention may be directed to:—

1 Feline Douroucouli (*Aotes felinus*), 2 White-browed Hares (*Sylvilagus superciliaris*), and 1 Collared Peccary (*Tayassu tajaçu*), from Banco, Colombia, presented by W. K. Pomeroy, F.Z.S., on May 3rd.

4 Patagonian Cavies (*Dolichotis magellanicus*) and 2 Golden Agoutis (*Dasyprocta agouti*), from Argentina, received in exchange on May 4th.

1 Reindeer (*Rangifer tarandus*), born in the Menagerie on May 9th.

1 Leopard Cub (*Felis pardus*), from Kongwe, Nyasaland, presented by Miss A. Winch on May 3rd.

1 de Winton's Mouse (*Mus sylvaticus wintoni*), from Horsham, new to the Collection, presented by Sir E. G. Loder, Bart., V.P.Z.S., on May 21st.

4 Siamese Fighting-Fish (*Betta pugnax*), from Siam, new to the Collection, presented by C. Lamont Groundwater on May 3rd.

Mr. E. T. Newton, F.R.S., F.Z.S., exhibited two horns of the Sabre-horned Antelope (*Oryx leucoryx*) not attached to the skull, but supposed to be a pair. The differences between the two horns, both as regards their curvature and peculiar annulation, raise a doubt as to their belonging to the same species, unless these differences may be due to sex. They are said to have come from West Africa. Each of these horns has about five inches of the basal portion covered in leather, with a large loop of the same material, which is evidently native work; but for what purpose this covering was intended is not clear. There is one horn in the British Museum which has indications of having been similarly covered.

A "nest"-making Chimpanzee.

Mr. George Jennison contributed the following note upon the "nest" made by a Chimpanzee in the Belle Vue Zoological Gardens, Manchester:—

A female Chimpanzee (*Anthropopithecus calvus*) was purchased for our collection on May 8th, 1913. She was not, in fact is not yet, adult, but had good health, and was kept until May 1914 in a rather small cage (12′ × 12 × 10′) having access to the open air. She was then removed to our new Chimpanzee house and installed in a large cage, through the middle of which there is a beam about 3 inches wide. Early in August it was noticed that she took a small supply of hay, or would even fray out a rope and lay it carefully along the beam and there lie.

We therefore nailed a rough branch horizontally from the beam to the wall, so enclosing a space of about 3 feet, and another cross-branch to make a very rough base, and provided a supply of hay, straw, and leafed twigs which were thrown on the floor ten feet below. Next morning the nest was partly made. Careful watching by W. Antcliffe, the keeper, showed that she carried up at first one or two straws and then proceeded to gather a bundle of twigs, which she tucked between one leg and her thigh, dragging herself to her nest by her arms and the other leg.

The twigs were carefully arranged with the leaves to the centre of the nest, and she also gathered up one of her swinging ropes, which she laid in short parallel lines on the twigs.

Mindful of Du Chaillu ('Exploration in Equatorial Africa'), we nailed suitable branches over the nest as a basis for a roof, but no attempt has been made to utilize them to form a shelter, as, of course, there is no rain in the house.

The animal spends most of her time in the nest, to which she carries all her food, even a glass of tea, which is taken up like the nesting material in the hollow of the thigh.

From time to time the nest is either thrown out or falls through, and is reconstructed with fresh material.

Having succeeded so well with this animal, similar facilities were given to three females (*A. troglodytes*) in the adjoining cage, but no attempt was made to use them. Nevertheless, although they usually sleep on the floor-level, they will carry a sack into their trees and sleep upon it. *A. calvus*, the "nest"-builder, will also take up a sack and sleep on it.

The Habits of Chimpanzees in African Forests.

Dr. C. C. Christy, M.B., C.M., F.Z.S., remarked "That it was somewhat misleading to talk of a Chimpanzee's nest. The little sleeping-platforms of the Chimpanzee made by bending inwards the leafy parts of two or three of the smaller branches of some sapling or larger tree, are quite a feature of the Ituri forests.

"They are generally close to the stem, and often comparatively low down, sometimes as low as 15 feet from the ground.

"They are small structures, are occupied by one or a pair of animals, and are never used a second night. They are made in a minute by reaching out and pulling in the branches, bending them or breaking them off.

"Chimpanzees feed largely on the ground, but I am doubtful if they ever sleep there. They are extremely wary and noisy. When met with in the daytime they are usually in the trees. At the first alarm the big males come down from any height in two swings and a drop and make off, but the females and rest of the troop swing and climb slowly from branch to branch. They rarely jump as monkeys do, and being too clumsy to travel quickly are easily overtaken. For such a big strong animal they are extraordinarily easy to kill. One serious body wound with a little ·22 bullet is sufficient to bring them down. A slightly wounded one will make for the top of a big tree, and by breaking off branches and pushing them beneath him will in less than a minute construct a big platform, upon which he will sulk or keep up a furious screeching entirely hidden from beneath."

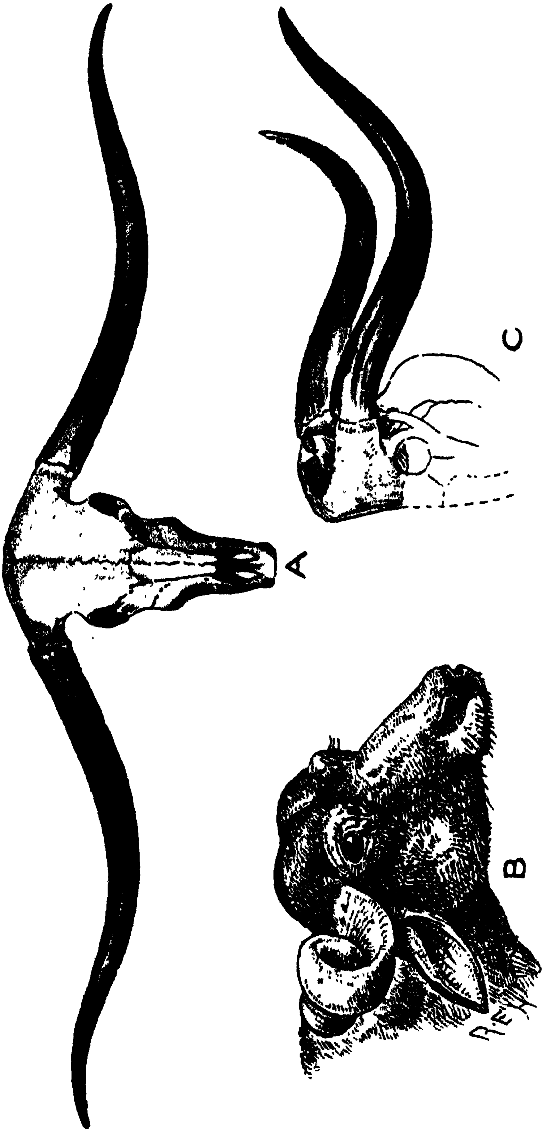
Variation in Horns of Cattle.

Mr. R. E. Holding exhibited and made remarks on several specimens indicating variation in the horns of certain local breeds of West-African humped cattle—viz. a single horn of the Gnami or Botlitli cattle from the neighbourhood of Lake Gnami, of which a fine skull has recently been added to the British Museum (Nat. Hist.). The horn exhibited is 4 ft. 5 in. long over the curve, and if say 11 inches were allowed for width of skull, the total measurement from tip to tip equals 9 ft. 9 in.

The specimen exhibited was part of a cargo of West-African horns recently sold in London.

The other West-African specimen, also of the humped breed, was a pair of lyre-shaped black horns. The frontal bone was rounded considerably, thus giving the horns a posterior direction reaching over the withers, the points turning outward. It is apparently a common breed. Length of one horn 36 inches.

Text-figure 1.



A. Skull and horns of Guam Ox. recently presented to the British Museum (Nat. Hist.) by Mr R. A Bailey. Resident Magistrate, Ngamiland. Length from tip to tip over the curves 10 feet.

B. Horn of "Delhi" variety of domesticated Indian Buffalo, placed on a drawing of the head of an Indian Buffalo to show actual position.

C. Lyre-shaped horns of N.W. African black variety of humped cattle.

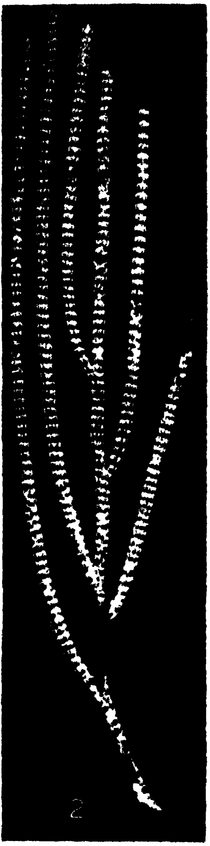
The pair of Indian horns shown were those of the "Delhi" variety of the domesticated Indian Buffalo (*Bos bubalus*), of which there are several local varieties—viz. Deccani, Kathiwar, and others. The specimen was of unusual form—massive at the base, with a compressed spiral growing backward.

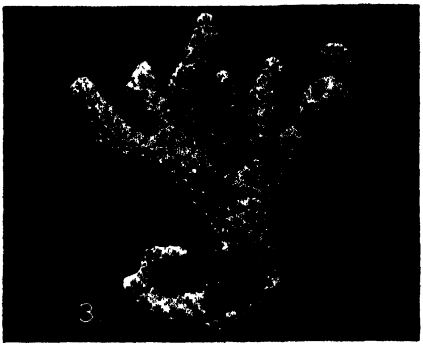
Mr. Holding also exhibited a print from a German colonial paper showing another variety of these long-horned cattle from Ruando, N.W. Africa, where considerable herds are owned by the Sultan.

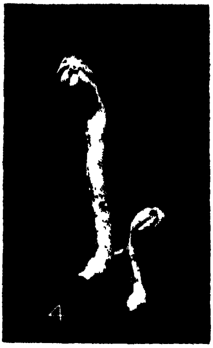
Humming-birds in Captivity.

Mr. Alfred Ezra, F.Z.S., exhibited a living specimen of Ricordi's Humming-bird (*Sporadinus ricordi*) and made the following remarks:—

"This little bird was brought over from Cuba by a dealer twelve months ago in almost a dying state. Having been fed only on sugar and water on the voyage, he was extremely weak and not able to move from his perch. His feathers were stuck together with the sticky syrup, and the bird looked miserable, not being able to make use of his wings. The first thing I did was to wash him (a difficult matter with such a little mite) in warm water with a drop of brandy in it, and after drying him thoroughly he was put back into a cage near a fire. In half an hour he was buzzing about in the cage and looked much happier. I fed him as I do my sun-birds, and he took to the food at once. For the first three nights I kept the light on for him to feed by, and in a week's time the bird began to pick up, and grew stronger every day. About November last he went through a partial moult, and again this April he went through a very heavy moult and got over it perfectly. He is kept in a fair-sized wire cage, and is given his freedom in a large room every morning for an hour, when he darts about at a terrific pace and enjoys it immensely, returning to his cage when he has had enough. It is astonishing to see how he will never knock himself against the window as most birds would do, but will always pull up just in time, no matter what pace he is flying at. Besides the syrup, which is his chief food, he will eat grapes and aphides, but I do not think the latter are essential, he having done quite well without them for all the long winter months. All his food is taken on the wing, which gives him plenty of exercise, and I am sure my success is due to this. He will not eat the aphides unless they are flying about, and I have never seen him pick one up, even if he sees them crawling on his perch. If some are lying at the bottom of the cage he will fly at a great pace close to them, and when they fly up he will swallow them one after another quickly. The bird is sprayed with tepid water every morning, no matter what the weather is like, and then he will wash himself by flying in and out of the damp leaves of a small plant placed in the cage. He loves the sun, but seemed quite happy without it through the winter. For a song he makes a sound like the sparks of a wireless at work. I think that so long as the birds have artificial light to feed by in the long winter nights for two or three hours, they do quite well. They must be kept warm, for as soon as the temperature drops below 65 degrees they begin to look unhappy. I had a very extraordinary experience with a Garnet-throated Carib (*Eulampis jugularis*), which was sent to me by a friend from Paris last May. It was brought over by a friend in a small cage which was well wrapped up. When I got the bird home I found him lying at the bottom of the cage, as I thought, dead. He was stone-cold to the touch and showed absolutely no signs of life. I took the bird in my hand into a very warm room, where, after about half an hour, I suddenly felt his heart beat; then he opened one eye and then the other, and put his long thin tongue out. I put the tongue into some hot syrup, to which I had added a drop of brandy. He instantly started to feed, and in another few minutes was flying about the cage. In ten days this bird was perfectly well, and I still have him in perfect health, and he is just going through his second moult with me. It was a very cold day when he was sent over from Paris, and I think the cold and the want of food were too much for him. Most humming-birds, I believe, go into a sort of torpor as soon as the temperature goes down below a certain point. Both my humming-birds are most pugnacious and have to be kept in separate cages. To my mind, they are the most intelligent and fascinating of all birds. My sun-bird mixture is made up in the following way:—I mix into a paste one heaped-up tea-spoonful of Mellin's food, one tea-spoonful of honey, half a tea-spoonful of Nestlé's milk, and the inside of about a dozen meal-worms, and add to this a large breakfast-cupful of boiling water. All my sun-birds have thriven on this food, and I have one now that I have had for five years and it is still in perfect health. I use the same food for the above two humming-birds—the first and only ones I have ever had—with great success."







1. PSAMMOGORGIA TERES. 2. CALIGORGIA FRASERI.
3. STYLASTER NORVEGICUS. 4. CLAVULARIA MORESBII.

PAPERS.

37. Some Alcyonaria and a *Stylaster* from the West Coast of North America. By Sydney J. Hickson, M.A., D.Sc., F.R.S., F.Z.S., The University of Manchester.

[Received July 14, 1915; Read October 26, 1915.]

(Plate I.* and Text-figures 1-5.)

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Although there have been several contributions to our knowledge of the marine fauna of the north-west coast of the American continent in recent years, the Alcyonaria are almost unknown. A long while ago specimens of a very large and remarkable Sea-pen (*Osteocella septentrionalis*), from the British Columbian fishing-grounds, were examined and described, but apart from this solitary example there is no record in the literature of Zoology, so far as I have been able to discover, of any other species of the Alcyonaria from this region.

The division of sea-areas into zoo-geographical regions is always a matter of great difficulty and controversy, and particularly so along an uninterrupted coast-line extending from the Arctic Circle to the Equator. Nevertheless, the study of the marine fauna of the western coast of the North American continent shows such changes in character as we pass from north to south, as to justify an attempt to name and define regions of distribution.

Such an attempt will not be made in this paper, but there is just one point bearing upon this division into regions upon which the study of this very small collection of Alcyonarians may throw some light.

In his papers on the Mollusca of the west coast of N. America, Dall (1898) has given the name Oregonian region to the shore-waters extending from Point Conception, near the south boundary of Upper California, to, and including, the Aleutian Islands.

Subsequent authors have noticed a remarkable change in the character of the fauna in the neighbourhood of the Straits of Fuca, the exit of Puget Sound, which would justify the subdivision of Dall's Oregonian region into two nearly equal subregions, one north and the other south of the British-American frontier.

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* For explanation of the Plate see p. 557.

There is, of course, no zoo-geographical barrier between these two subregions, and we should expect to find considerable overlapping, some of the characteristic southern genera appearing in the northern subregion and *vice versa*.

One of the characteristic features of the northern subregion is the occurrence of genera and even species that are familiar to us on our North Atlantic coasts, suggesting that they are the representatives of a circumpolar fauna. Thus Professor Herdman (1898, p. 249), writing about some simple Ascidians collected in Puget Sound, says, "I think it may with truth be said that all the Ascidians I collected in this arm of the N. Pacific are closely related to familiar species on our own North Atlantic coasts. This, taken with the similarity between the two faunas shown in other groups, suggests the possibility that there is a common northern circumpolar marine fauna which extends southwards on the western coasts of Europe and America." This view is supported by Walker (1898, p. 269), who says, in writing on the Crustacea collected by Herdman in the same locality, "Besides the species in the collection that are absolutely identical with the British species, the resemblance between others is remarkable."

In an account of the Hydroids of the Alaskan expedition (1910, p. 179), Nutting gives reasons for believing that Puget Sound is a natural region of demarcation between faunæ, but Fraser (1911), in his account of the Hydroids of the Vancouver Island region, considers that there is no justification for a statement that there is a distinct break at any point along the coast. "At the present time," he says (p. 7), "out of a total of 196 species there is a record of 155 species from the Vancouver Island region and north of it, and 88 south of that region. No less than 47, or 24 per cent. of the whole number, are common to the two. Furthermore, 22 species that are found north of Vancouver Island are found in the Vancouver Island region as well as in the region south of it."

As regards the Alcyonarian fauna of the Oregonian region, we possess some knowledge of the genera and species found on the coast of California, *i. e.* the southern subregion, thanks to the researches of Nutting and others, recently summarised and revised by Kükenthal (1913), and it is therefore of no little interest to compare them with the few species collected off Vancouver Island and in the Gulf of Alaska that are described in this paper.

The following is a list of species of Alcyonaria now known to occur in the region of Puget Sound and north of it:—

Clavularia moresbii.
Paragorgia arborea.
Primnoa willeyi.
Caligorgia fraseri.
Psammogorgia teres (sp. ?).
Osteocella septentrionalis.

Two of these six species belong to genera (*Paragorgia* and *Primnoa*) that do not occur in Kükenthal's list. As regards the Sea-pen, *Osteocella septentrionalis* (Hickson, 1911), it may be a matter of controversy whether we are justified in separating the species from the genus *Pavonaria*, of which two species (*P. californica* and *P. willemoesi*) have been described from Californian waters, but there seems to be little doubt that the species is quite distinct.

Clavularia moreshii is closely related to, but quite distinct from, the *C. pacifica* of Californian waters. The genus *Clavularia*, however, being cosmopolitan in distribution and having many very variable species, does not afford much assistance in the determination of marine zoological regions.

The genus *Psammogorgia*, on the other hand, appears to have principally a tropical and temperate distribution, and the occurrence of one species north of the Straits of Fuca may be regarded as an example of the fauna of the southern subregion overlapping the boundary-line. Three species of this genus have been described by Nutting from Californian waters, but I have found the determination of species of *Psammogorgia*, without the examination of type-specimens, so extremely difficult that I feel great hesitation in my identification of the Vancouver specimen as *Ps. teres* and can make no further comments upon it.

The genus *Caligorgia* has many species in the Pacific Ocean, but according to Versluys (1906, p. 169) it is unknown in the North Atlantic. The species found off the coast of California (*C. kinoshitæ*), however, is quite distinct from the species described in this paper from the Gulf of Alaska.

The occurrence of a specimen of *Stylaster* in the Vancouver seas is of interest, because it belongs to the same form or subgenus (*Allopora*) that occurs in the Norwegian fjords, and not to the form or subgenus (*Stylaster*) which is so common in tropical and subtropical waters. It has been previously described by Verrill from the coast of California, but is probably a migrant from the north.

To summarise the results, it may be said that in this small collection three species at least (*Stylaster norvegicus*, *Paragorgia arborea*, and *Primnoa willeyi*) are representatives of a circumpolar fauna, one (*Psammogorgia teres*) is a representative of the south coast fauna, and the other three (*Clavularia moreshii*, *Caligorgia fraseri*, and *Osteocella septentrionalis*) may represent a common Pacific element which extends both north and south of the line between the two subregions.

A comparison of the list of species described in this paper with Kükenthal's list of Californian species shows that not a single species of Alcyonaria (except possibly the *Psammogorgia*) has been found both north and south of the Straits of Fuca, and seems therefore to justify a division of the Oregonian region at that point into two subregions. The specimens I have been able to collect together may represent only a small fraction of the

Alcyonarian fauna of the Columbian and Alaskan waters, and subsequent researches may modify any deductions that may be drawn from them, but so far as our knowledge extends at present the facts are significant.

I wish to acknowledge my indebtedness to Professor A. Willey, F.R.S., and to Mr. McLean Fraser for the specimens described in this paper; to Miss Constance M. Lightbown, B.Sc., for much valuable assistance in making preparations and drawings, and to Mr. J. T. Wadsworth for taking the photographs (Pl. I.) and for the drawing of text-figure 3.

Order STYLASTERINA.

STYLASTER (ALLOPORA) NORVEGICUS Gunnerus. (Pl. I. fig. 3.)

Millepora norvegica Gunnerus, 1768.

Allopora californica Verrill, 1868, Essex Inst. vol. v.

Allopora oculina Moseley, 1881, 'Challenger' Reports, vol. ii. p. 85.

Stylaster norvegicus Broch, 1914, Danish 'Ingolf' Expedition.

Swiftsure Shoal, off Barkley Sound, W. coast Vancouver Island.

Local name. Roseate stag's horn coral.

A single dried specimen of this *Stylaster* was taken by Professor McMurrich from the Swiftsure Shoal.

It is 45 mm. in height, with seven short blunt branches arranged in a single plane. One of the branches shows a barnacle-gall. As there is no base of attachment, the specimen may be a branch of a much larger colony.

The main stem is 10 mm. in diameter, and the branches about 5 mm. in diameter.

The cyclosystems are evenly distributed on all sides of the branches, and they are not more numerous on one side of the flabellum than on the other. Each cyclosystem projects slightly from the surface of the cœnosteum and is about 0·75 mm. in diameter.

The number of dactylopores in each cyclosystem varies, but in the majority of cases there are 6 or 7. There is a large brush-like style in the gasteropore and a very small style in each of the dactylopores. No ampullæ can be seen on the surface of the cœnosteum, but at the broken base a few small cavities (0·5 mm. in diam.) may be seen which are probably young ampullæ.

The colour is salmon-pink.

The difficulty of separating the two Stylasterid genera *Allopora* and *Stylaster* was pointed out ten years ago by myself and Miss England (1905, p. 6). Broch (1914), agreeing with our view on this matter, has included *Allopora* in the genus *Stylaster*, retaining the name *Allopora* as a subgeneric name for species of *Stylaster* included in our group of species D. "For group D the old generic name *Allopora* should be retained." This is clearly an error. According to our definition of the groups, group D has cyclosystems on the anterior surface of the branches only. It is group C which has the cyclosystems evenly distributed over the surfaces of the branches. In *Allopora norvegica*, according to Broch's own description and figures of the species, as well as in the Cape species (*Allopora nobilis*), the cyclosystems are distributed on all sides of the branches, they are certainly not confined to the anterior surface of the flabellum, as they are in the species of our group D.

The subgenus *Allopora*, however, is usually distinct from the other subgenus *Eustylaster* of Broch, not only in the character given to our group C—that the cyclosystems are distributed on all surfaces of the branches,—but also in two ill-defined but still mutually dependent characters, namely, that the terminal branches are relatively thick, and that the ampullæ do not project or project slightly from the surface of the cœnenchym.

Returning now to our species from Vancouver Island. It clearly belongs to our group C, as the cyclosystems are more or less evenly but irregularly distributed on all sides of the branches. It may therefore be placed in the subgenus *Allopora* of the genus *Stylaster*. The determination of the species is a much more difficult matter in the absence of any information about the ampullæ or gonophores. The characters of the cœnosteum, as seen without fracture, are similar to those of the species from the Norwegian coast except in respect of colour, which is salmon-red instead of white or faintly rose. The colour-difference by itself does not seem to me to be a character upon which it is wise to establish a distinct species, and therefore I am disposed to regard the species as identical with the Norwegian species.

The proper name of this species has recently been discussed by Broch (1914, p. 17), and I am in agreement with him that it should stand as *Stylaster* (*Allopora*) *norvegicus* Gunnerus. Whether this species is identical or not with the *Allopora oculina* of Ehrenberg cannot be determined with any degree of certainty, but there can be little doubt that it is the same as the *Allopora oculina* of Moseley's 'Challenger' Report (1881, p. 85).

It seems very probable that the species is also identical with Verrill's *Allopora californica* from deep water off the coast of California. Verrill's specimen was 3 inches (75 mm.) or more in height, had cyclosystems ·02 inch (0·5 mm.) in diameter, with, usually, six dactylopores, and was light "minium" red in colour. From the description there are no points of distinction of this form from *Allopora norvegica*, except colour.

Note on the Gonophores of the Stylasteridæ.

In his recent work, Broch (p. 20) attributes to Moseley the view that the gonophore of the Stylasteridæ is a special formation in the group, and is not homologous with the adelocodonic gonophore of other Hydrozoa. This was certainly not Moseley's view, and when I suggested it to him he expressed to me personally his disagreement with it. The term "trophodisc" was suggested by myself and was never used by Moseley at all.

As regards the view itself. It was expressed as a result of a long investigation of the development of the gonophores of a *Stylaster* (*Allopora*) from the coast of Norway, and every fact described was confirmed by the examination of many comparable preparations. Knowing now, after twenty-five years' experience of this group, better than I did then, the difficulty of the investigation, I realise the probability that some stages in the development may have been missed. Moreover, the study of Kuhn's excellent memoir on the development of the gonophores of Hydrozoa has to some extent shaken my faith in my own view; but the homology of the gonophores of Stylasteridæ with the adelocodonic gonophores of other Hydrozoa has not yet been proved, and will not be established by scattered observations on a few stages of the development of the male gonophore alone. The principal difficulty in accepting the older view held by Moseley arose from my observations on the development of the female gonophore, and until this investigation has been repeated with more modern methods of study than I had at my disposal in 1890, the true homologies of these organs must remain undetermined. In the meantime the discovery that *Millepora*, notwithstanding its calcareous skeletal structures, does give rise to free-swimming medusæ, has removed one of the principal initial difficulties I felt in believing that the gonophores of Stylasteridæ could represent reduced medusæ, and I am quite prepared, when the time comes, to abandon my own view in favour of the more conventional and older one of Moseley.

Order ALCYONARIA.

Family CLAVULARIIDÆ.

CLAVULARIA MORESBII, sp. n. (Pl. I. fig. 4; Text-fig. 1.)

W.S.W. off Moresby Island, 100 fathoms.

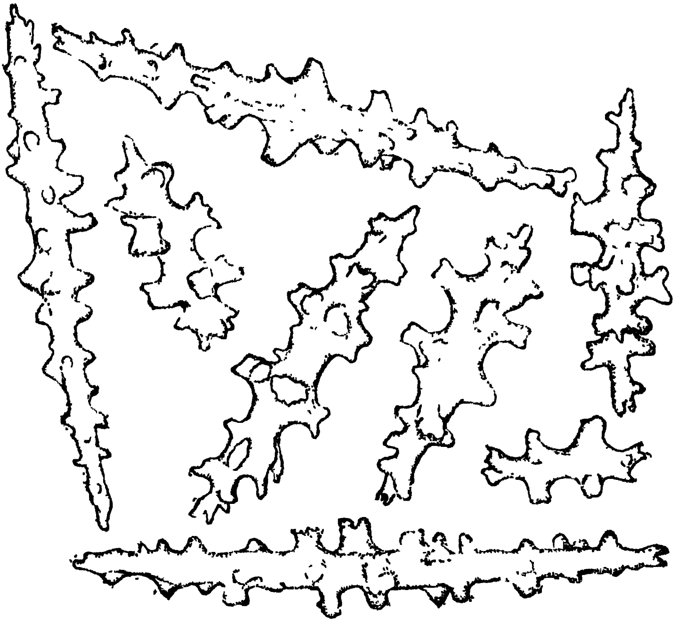
The widely distributed and very variable genus *Clavularia* is badly in need of revision. It is probable that such a revision would lead to a considerable reduction in the number of the species, many of which have been founded on very inadequate characters. Nevertheless, the specimens from Moresby Island show very distinct specific characters and must be regarded as the type of a new species.

The genus is well represented both in the Norwegian waters and in the North Pacific Ocean. The occurrence of a species in British Columbian waters might have been anticipated, and in itself is not a fact of any zoo-geographical importance.

The specimens were obtained by Prof. Willey in 1914, who writes that these whitish "rose-headed" Clavularias were growing on the stem of the Gorgonid (*Primnoa willeyi*). They were preserved and forwarded to me in formalin.

The stolon is in the form of flat anastomosing bands, spreading out in places and fusing to form membranes. From the stolon the zooids arise in a very irregular manner, in some places at considerable intervals, in others close together. The stolon follows the support in a quite irregular manner, and, so far as can be determined from the material at my disposal, is never thickened to form a sympodium. The zooids are never retracted into the stolon, but they all show the tentacles contracted tightly over the oval disc. They vary very much in size, large and small ones being irregularly distributed on the stolon.

Text-figure 1



Spicules of *Clavularia moreshii*. × 350 diam.

The larger zooids are from 7–10 mm. in length, with a diameter of 2 mm. The crown of tentacles is never retracted into a calyx, and the aboral surfaces of the eight tentacles forming the apex of the zooid, in the preserved state, therefore can always be seen. The body-wall is smooth and cylindrical. It does not shew, as preserved, the eight longitudinal furrows that have been described in many other species of the genus.

The spicules (text-fig. 1) are tuberculated spindles 0·15 mm.–0·2 mm. in length by about 0·05 mm. in diameter, and do not shew a tendency to become club-shaped. They are densely crowded both in the tentacles and body-wall, and are nearly all arranged in a direction parallel with the long axis of the zooid.

The species seems to be most closely related to *Clavularia pacifica* (Kükenthal, 1913, p. 237) from the coast of California, previously described by Nutting (1909, p. 686) as *Sympodium armatum*. This species, however, differs from *Clavularia moresbii* in having stouter and more retractile zooids (5 mm. × 2 mm.), with eight deep longitudinal grooves and larger spicules (0·25–0·3 mm. in length). The spicules, moreover, are much more crowded together in *Clavularia moresbii*, and do not show in such marked degree as in *C. pacifica* a transverse disposition at the base of the tentacles, and I cannot find in my preparations any spicules that by becoming thickened at one end show a tendency to be club-shaped.

In *Clavularia eburnea* (Kükenthal, 1906, p. 14) from Japanese waters the zooids are larger (12 mm.), but in the spicular armature and in other characters *C. eburnea* is more closely related to *C. pacifica* than it is to *C. moresbii*.

But, although the relationship of our new species with the Californian species *C. pacifica* is pronounced, it must be pointed out that its relationship with some of the Norwegian species, such as *C. borealis* of Koren and Danielssen (1883, pl. i.), may be as close, and it affords therefore no special reason for regarding the fauna of British Columbia as being more closely related to the Pacific than to the N. Atlantic fauna.

Family BRIAREIDÆ.

PARAGORGIA ARBOREA Linn. (Text-fig. 2.)

Alcyonium arboreum Linnæus, Syst. Nat. 10th edit. 1758, p. 803.

Alcyonium arboreum Pallas, Elenchus Zooph., Edit. Wilkens, 1787, pt. 2, p. 164.

Paragorgia arborea Milne-Edwards, Hist. Nat. Cor. 1857, t. 1, p. 190.

Paragorgia nodosa Koren & Danielssen, Nye Alcyonider, etc. 1883, p. 19.

? *Paragorgia nodosa* Nutting, Pacific Alcyonaria, 1912, p. 99.

? *Paragorgia regalis* Nutting, l. c. p. 100.

Off Kodiak Island, Gulf of Alaska. Depth ? 1 specimen.

Local name. Friable brick-red coral.

In Wilkens' edition of Pallas' 'Elenchus Zoophytorum' there is a long account of this species, probably copied in great measure from the writings of Koelreuter (1761). There can be no doubt from this that the *Alcyonium arboreum* of Linnæus and Pallas is the same species as the common species of the Norwegian fjords, now known as *Paragorgia arborea*.

Although the external features of the species were fully described by Koelreuter, and measurements and illustrations of the spicules of *Paragorgia nodosa*—which does not seem to me a distinct species—are given by Koren and Danielssen, there is no good modern description either of the genus or species.

The genus, however, seems to be quite well distinguished from others of the same family by the very well-marked dimorphism of the zooids and by the characters of the spicules. The occurrence of dimorphism in the genus, first recorded by myself in 1883, is of importance because it is of only exceptional occurrence in the *Pseudaxonia*, and can be clearly determined, not only in fresh and spirit specimens, but also in specimens that have been dried for many years.

The geographical distribution of *Paragorgia arborea* cannot be very accurately determined from the literature. It is probable that some of the specimens from the Mediterranean Sea and Atlantic Ocean, refered to *Alcyonium arboreum* by the older naturalists, belonged to a different genus or species. Of recent years there is no record of any specimens being found outside the area of the Norwegian coasts. It was not found by the 'Challenger' Expedition in the Atlantic, nor is it recorded from the deep water off the west coast of Ireland by the Irish Fisheries Investigations.

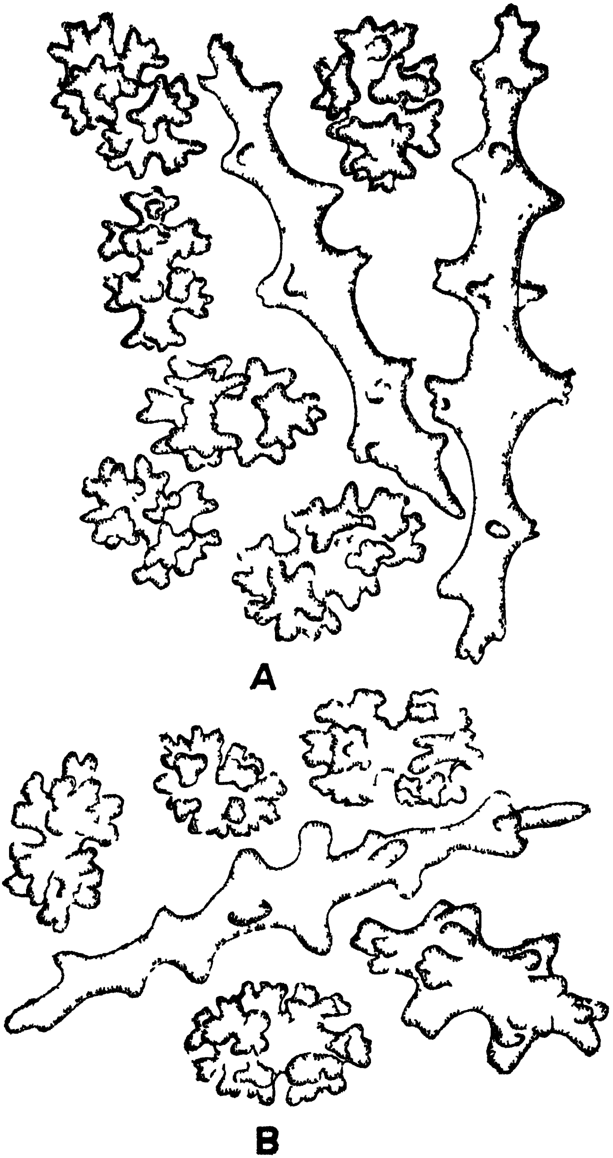
It was therefore with some surprise that I found, in the collection sent to me by Mr. Fraser from the Gulf of Alaska, a specimen that was clearly a species of *Paragorgia*. For comparison with the Alaskan specimen I have examined a specimen of *P. arborea* from the Trondhjem Fjord, and I have no hesitation, after making this comparison, in placing the two specimens in the same species.

The specimen is probably only a fragment of a large colony, but it shows a simple bifurcation at the distal end. It is 170 mm. in length. The stem at the base is oval in section (14 × 18 mm.). As in the specimen from Norway, the stellate pores of the autozooids are scattered irregularly in clusters all round the stem, many of the clusters being mounted on dome-shaped prominences from the surface. The pores of the siphonozooids are numerous, quite irregularly distributed, and easily seen with a hand-lens. The axial part of the stem is creamy-white in colour, and is penetrated by canals corresponding in arrangement with those in my specimen of the type-species. The crust, or outer layer, of the stem is about 1 mm. in thickness, and is distinguished by its brick-red colour.

The spicules of the autozooids are irregularly tuberculated spindles, of which the larger ones are about 0·25 mm. in length. These spicules are probably distributed in the tentacles or body-wall of the anthocodiæ of the autozooids, but I cannot determine this with certainty.

The spicules of the cœnenchym and axial region are double stars of the type shown in Kölliker's 'Icones,' pl. xviii. fig. 45. They are of nearly constant size, 0·07 mm. in length.

Text-figure 2.



A. Spicules of *Paragorgia arborea* from Alaskan coast. × 375 diam.

B. Spicules of *Paragorgia arborea* from coast of Norway, for comparison with A. × 375 diam.

A comparison of the preparations of spicules, made from the Alaskan specimen and from the Norwegian specimen, shows that there is very little difference either in size or shape between the spicules of the two specimens. In fact, the preparations can hardly be distinguished without the assistance of the labels (text-fig. 2, A, B).

In a recent paper, Nutting (1912, p. 99) has described two species of the genus from the Japanese seas, one he attributes to the species *P. nodosa* of Koren and Danielssen and the other to a new species, *P. regalis*. It does not appear to me that either of these species is very well defined from the type-species, but without examination of type-specimens from Japan it is impossible to determine with certainty whether they are identical with *P. arborea* or not.

Family PRIMNOIDÆ.

Subfamily PRIMNOINÆ.

PRIMNOA WILLEYI, sp. n. (Text-fig. 3.)

Locality. W.S.W. off Moresby Island, British Columbia, 100 fathoms.

Concerning this species Prof. Willey writes: "In fishing for halibut a magnificent scarlet Gorgonid was brought up on one of the hooks. It was four feet in height, with a diameter at the broken off base of 1·5 inches. The branches anastomose and the axis is black and horny."

Specimens of the *Clavularia* described above were growing on the base of the horny stem of this *Primnoa*.

The only specimens sent to me were a number of fragments well preserved in formalin. I am unable therefore to give an account of the colony as a whole or its method of branching. The method of branching, so far as I can judge, is dichotomous, but I have no evidence of the anastomoses referred to by Prof. Willey.

The structure and arrangement of the zooids, however, afford sufficient evidence to show that the species is not identical with any that has hitherto been described.

At the time of the publication of Versluys' memoir on the Primnoidæ (1906), there was only one well-established species of the genus, the well-known *Gorgonia reseda* of Pallas, subsequently called *Primnoa lepadifera* by Lamouroux.

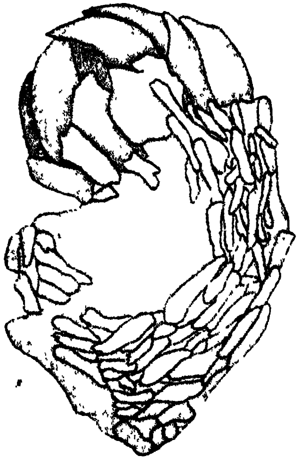
Since that date Kinoshita (1908, p. 42) has described a new species, *Primnoa pacifica*, from the Sagami Sea.

The genus *Primnoa* is distinguished from other Primnoinæ by the irregular distribution of the zooids on the branches—or, in other words, the zooids are not arranged in definite whorls nor in definite spirals. Moreover, it seems to be a character of the two known species that the zooids are bent downwards away from the apex of the branches, instead of upwards towards the apex of the branch, as they are in most of the Primnoinæ.

In the specimen from British Columbia, the terminal branches including the zooids are about 6 mm. in diameter and excluding the zooids about 3 mm. in diameter. The zooids are quite irregularly distributed on the branches, larger and smaller ones being mixed, and they are all bent downwards towards the base of the branch. The larger zooids are about 5 mm. in length by about 1·5 mm. in diameter.

The opercular scales are triangular in shape, with a very well-marked keel passing along the adoral side from the apex towards the base. These scales are 1·5 mm. in length (from apex to base) and 0·6 mm. in breadth. Behind and partly overlapping the opercular scales on the abaxial side there is a half circle of large oblong scales 1·05 × 0·75 mm., and arranged very irregularly over the rest of the abaxial side there are long narrow scales of various sizes up to 1·8 mm. in length by 0·2 mm. in breadth (text-fig. 3). Some of these elongated scales occur on the adaxial side of the margin of the zooid overlapping the opercular scales, but the greater part of this side of the zooid is naked.

Text-figure 3.



A single zooid of *Primnoa willeyi*. × 15 diam.

In *Primnoa reseda* and in *Primnoa pacifica* there is less difference between the marginal scales and the other scales of the abaxial side of the zooids, and in both these species the zooid is more completely covered and protected by square or oblong scales.

The new species differs from both the other two species, not only in the shape and arrangement of the scales as described above, but also in the actual size of the larger zooids.

I have compared them with the zooids of a specimen of *P. reseda* from Norway, and found that, whereas the measurements of spirit specimens of *P. willeyi* are 5 mm. by 1·5 mm., in dry specimens of *P. reseda* they are 7 mm. by 3 mm. In *P. pacifica* the zooids are said to be 5–7 mm. in length, and from the figure are evidently broader and stouter than in *P. willeyi*.

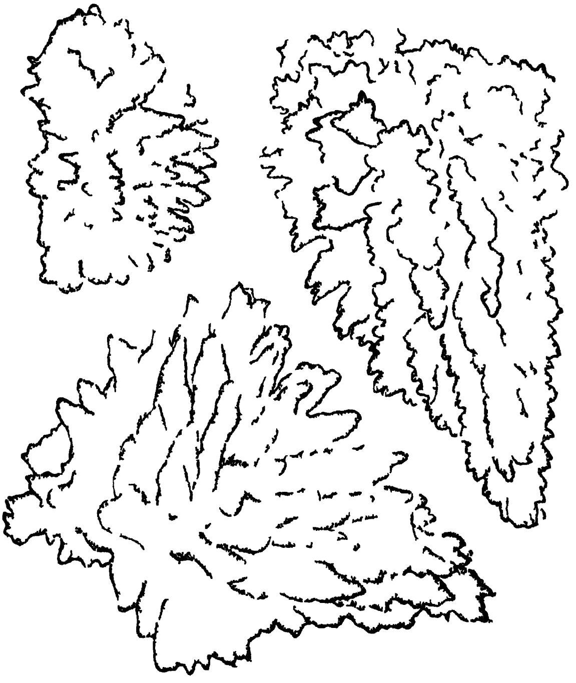
CALIGORGIA FRASERI, sp. n. (Pl. I. fig. 2, text fig. 4.)

Gulf of Alaska, 50–100 fathoms.

Local name "Verticillate fan coral."

This new species is represented by two dried specimens 220 and 130 mm. in length respectively. The base of attachment is missing from both specimens, and consequently they may represent portions of a larger colony. The branches arise alternately, but irregularly, from the main stem (or branch) in one plane. The diameter of the largest stem, including the whorl, is 3·5 mm., and of the axis 2 mm.

Text figure 4.



Scales of *Caligorgia fraseri*. × 280 diam.

The zooids are arranged in closely-set but not overlapping whorls. In the thickest branches there are 11 or 12 zooids in each whorl, but they diminish to 5 or 6 in the more slender distal branches. The zooids are about 1 mm. in length by 0·5 mm. in diametor, and are closely adpressed to the side of the branch.

The zooids are protected on the abaxial side by three or four longitudinal rows of overlapping scales, but the axial side is free from scales except at its distal extremity. The apex of each zooid is protected by a complete circle of triangular opercular scales.

The large abaxial scales are round or oval in shape, and the outer surface is ornamented with numerous long spiny tubercles which radiate outwards from a common centre.

It is the presence of these remarkably long tubercles on the scales that constitutes one of the most important characters of the species. These scales attain a size of 0·3 mm. × 0·23 mm. The triangular opercular scales are also covered with long tubercles, and their size may be 0·28 mm. in height by 0·2 mm. at the base.

In addition to the abaxial plates and opercular scales, a preparation of the spicules of a zooid reveals a number of smaller scales and irregular tubercular calcareous nodules. The exact position of the latter cannot be determined owing to the density of the plates which cover them, but they probably correspond with the deep-seated warty sclerites described by Versluys (1906, p. 76) in *Caligorgia ventilabrum*, but far more commonly found in the genera *Primnoella* and *Primnoides*. The presence of these sclerites constitutes a second important character of the species.

The new species appears to be most closely related to *Caligorgia aspera* (Kinoshita, 1908, p. 39) from the west coast of Satsuma, Japan, from which it differs in the less profuse branching, in the smaller number of zooids in a whorl, as well as in the larger and more profuse tuberculation of the scales.

In the method of branching it is more like *C. granulosa* of the same author (p. 37), but in this species the scales are much larger. In *C. elegans* (Gray), also described by Kinoshita from the coast of Japan (p. 40), the number of zooids in a whorl corresponds more closely with that of the new species, but the tubercles on the scales are much smaller.

The specimens were taken on the Halibut lines on Albatross and Portlock banks, in the Gulf of Alaska, and are said to be pink when fresh and to be "common." They were collected by Professor A. Willey, F.R.S.

Family PLEXAURIDÆ.

PSAMMOGORGIA TERES Verrill. (Pl. I. fig. 1; Text-fig. 5.)

Psammogorgia teres Verrill, Trans. Conn. Acad. vol. i. 1868, p. 416.

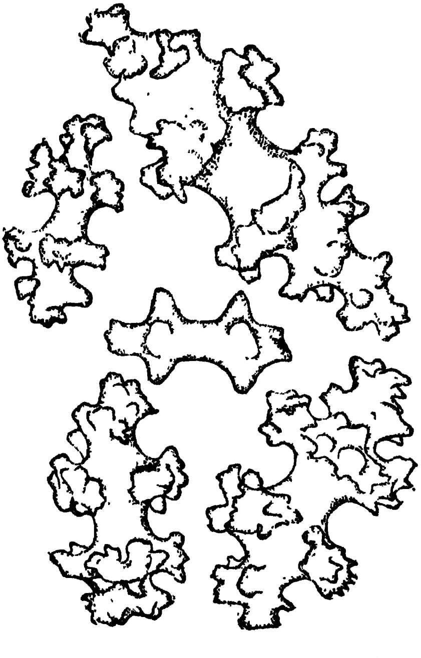
W. coast of Vancouver Island.

Local name. Coral-pink candelabrum coral.

The genus *Psammogorgia* is so badly in need of revision and full description that I refer this specimen to Verrill's species with the greatest hesitation. The type of the species was taken off Pearl Island, which I believe to be off the west coast of tropical America, in 6–8 fathoms, and is said to be rare.

The specimen from Vancouver Island is dry, and, in the presence of a flattened base of attachment, is evidently complete. It is 115 mm. in height and has six branches. The diameter of the thickest branch is about 4 mm., and the branches are almost cylindrical in shape. The diameter of the axis just below the point where ramification begins is 4 mm., and the disk of attachment is thin and about 10 mm. in diameter. The crust varies in thickness from about 0·25 mm. below to 1 mm. near the terminal ends of the branches.

Text-figure 5.



Spicules of *Psammogorgia teres*. × 500 diam.

The positions of the zooids are marked by flat or slightly convex prominences, quite irregularly distributed over the surface of the cœnenchym, and in the centre of each prominence there is a stellate aperture.

The spicules are tuberculated spindles, very variable in size, but with an average of about 0·12 × 0·04 mm., and double stars rather smaller in size (text-fig. 5).

The genus *Psammogorgia* is represented by four species from the tropical region of the west coast of America described by Verrill (1868), and by three species from the coast of California described by Nutting (1909, p. 719). In a recent paper Kükenthal (1913, p. 268) expresses the opinion that one of Nutting's species should be referred to the genus *Euplexaura* of Verrill, as amended by him.

It appears to me very doubtful whether the genus *Psammogorgia* will stand as an independent genus, but I am not disposed, until a further study is made of the species attributed to it from the west coast of America, to merge it into the more widely distributed genus *Euplexaura*. The diagnostic characters of the species are all most unsatisfactory, and it is almost certain that if the genus stands it will stand as a single-species genus. In the meantime, I refer the specimens from Alaska to the species to which they appear to be most closely related.

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EXPLANATION OF THE PLATE.

Fig. 1. *Psammogorgia teres* (dry). Nat. size.
2. *Caligorgia fraseri*, sp. n. (dry). Nat. size.
3. *Stylaster norvegicus* (dry). Nat. size.
4. *Clavularia moresbii*, sp. n. Two zooids preserved in spirit. × 2 diam.

[NOTE.

My attention has been called to a paper by W. H. Dall, "On some Hydrocorallinæ from Alaska and California," in the Proc. Biol. Soc. Washington, vol. ii. 1885, p. 111.

In this paper three new species of *Allopora* are described from the Aleutian and Shumagin islands, namely, *A. verrillii*, *A. moseleyi*, and *A. papillosa*.

They differ in some respects from the specimen I have identified as *Stylaster* (*A.*) *norvegicus* from the Swiftsure shoal off Vancouver Island, but I do not consider, without reference to the type specimens, that these differences are sufficient to justify a specific distinction from the older species.

In this paper there is also a record of a specimen identified as *Calligorgia compressa* Verrill from the Aleutian islands, but as there is no figure or description of it, comparison with the specimen described by me as *Caligorgia fraseri* cannot be made. The type specimen of *C. compressa* is (*fide* Versluys, p. 81) only a naked axis without polyps or spicules.

December 13, 1915. S. J. H.]

38. On Specimens of Cuvier's Whale (*Ziphius cavirostris*) from the Irish Coast. By SIDNEY F. HARMER, Sc.D., F.R.S., F.Z.S., Keeper of Zoology in the British Museum *.

[Received October 15, 1915: Read October 26, 1915.]

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Among the Cetacea included in lists of the British species, the subject of this notice is one on which further information is specially desirable. Its claim to be regarded as British was established by Professor (now Sir William) Turner (1872, 1912), on the evidence of a skull obtained off Hamna Voe, Northmaven, Shetland, and now in the Anatomical Museum of the University of Edinburgh. So far as I have been able to ascertain, this is the only authenticated record of the occurrence of *Ziphius cavirostris* in the British area. Van Beneden indeed states (1888, pp. 87, 91) that a male specimen of this species was stranded on the Irish Coast (place and date not indicated), and that its skeleton is in a Dublin Museum. In order to obtain information with regard to this record I wrote to Dr. R. F. Scharff, Keeper of the Natural History Collections in the National Museum, Dublin, who has been good enough to inform me that he knows nothing whatever of the supposed *Ziphius*, and suggests that Van Beneden may have mistaken a record of an Irish *Mesoplodon bidens* for one of *Ziphius cavirostris*. He assures me that the National Museum at Dublin possesses no skeleton of *Ziphius* or any part of one; and that he has satisfied himself that no such skeleton exists in the Museum of the Royal College of Surgeons, Dublin, or in that of Trinity College, Dublin.

Although I am thus unable to ascertain what was the evidence on which Van Beneden's statement was made, I am in a position to record the occurrence of two undoubted specimens of *Z. cavirostris* on the Southern Coast of Ireland. The circumstances under which these have been obtained by the British Museum lead me to suspect that the species is not so uncommon a visitor to our shores as has hitherto been supposed *. It seems not improbable that a certain proportion of the Cetacea recorded as "Bottle-nosed Whales" belong either to this species or to the allied genus *Mesoplodon*, of which two species appear to occur in our seas, namely Sowerby's Whale (*M. bidens*) and *M. europæus* Gervais, the validity of which has been the subject of much dispute, but which, from the evidence recently given by the late Mr. F. W. True (1910, p. 11), has considerable claims to be regarded as distinct from *M. bidens*.

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The adult males of Ziphioid Whales usually possess one or two pairs of large and conspicuous teeth, either at the extreme anterior end of the lower jaw or further back in the same jaw; and in most of the species these teeth form a conspicuous feature of the animal in the flesh. In young specimens of either sex and even in adult females, the corresponding teeth do not cut the gum, in most of the species; and a living specimen thus appears to be completely edentulous. While the adult male of the Common Bottle-nosed Whale (*Hyperoodon rostratus*) is characterised by its remarkably swollen forehead, this feature is absent from the females at all ages, as is shown in the figure given by Capt. David Gray (1882, p. 728). When it is remembered that the coloration of the skin is very variable, both in *Hyperoodon* and in *Ziphius*, it will be realised that the external differences between apparently edentulous specimens of these two genera are not so striking as to preclude mistakes in determination by observers who have not had considerable experience. In order to obtain any certainty with regard to the determination of Ziphioid Whales it is thus desirable to scrutinise most carefully the evidence relating to reputed "Bottle-nosed Whales."

The considerable number of records of the occurrence of *Ziphius* in the most widely separated localities, taken in conjunction with the evidence supplied by some of the best authorities that but a single recent species has been proved to exist, leads to the conclusion that *Z. cavirostris* is a cosmopolitan species which inhabits the open oceans of the world and is occasionally stranded. It does not follow that it is in reality a rare animal. If the conclusion that but one living species occurs be correct, the species has an almost world-wide distribution, since it has been recorded not only on both sides of the Atlantic and in the Mediterranean, but also in such widely separated localities as South Africa, New Zealand, and Bering Sea.

In 1912 the Board of Trade issued instructions to Receivers of Wreck to inform the British Museum of the stranding of Cetacea along the British Coasts; and as the result of this action a number of telegraphic intimations of such occurrences have been sent to the Museum from time to time. The telegrams thus despatched have in many cases been supplemented by written Reports, sketches, or photographs; and often by the transmission of lower jaws or other parts of the specimens stranded. From the information thus obtained two Reports have already been published by the Trustees of the British Museum (Harmer, 1914, 1915). For the assistance given to this enquiry by Receivers of Wreck and Coastguard officers I wish to express my most cordial thanks; and it is hardly necessary to add that a similar expression of gratitude is also due to the Board of Trade, by whose action the collection of this information has been rendered possible.

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* It is not impossible that two living Whales which were observed from the cliff at Great Saltee Island, Co. Wexford, June 15, 1913, by Mr. W. P. Pycraft, in company with the late Mr. R. M. Barrington and Mr. W. W. Grant, may have belonged to *Z. cavirostris*. Mr. Pycraft has kindly given me a copy of the notes which he made at the time, according to which all three observers were struck by the remarkably white appearance of the fore part of the body, and were agreed that this was not due to the effect of brilliant sunshine reflected from a black surface. The hinder part of the body was evidently darker than the front part. It will be noticed that this account is in complete agreement with the observations recorded below on the coloration of the Wexford *Ziphius* stranded on July 19, 1915.

In receiving these telegraphic Reports the possibility of adding to our knowledge of the rarer Ziphioid Whales has throughout been borne in mind; and in particular it was hoped that opportunities would be afforded of obtaining specimens of *Ziphius cavirostris.* The inauguration of the scheme was more successful than was suspected at the time; since the very first specimen received after it came into full working order, namely the Whale recorded in my 1914 Report as 1913, No. 1 (Unionhall, Co. Cork), ultimately proved to be a specimen of the wished for *Ziphius.* This discovery was only made a few weeks ago, on removing the skeleton from the sand-pit in which it had been cleaned *; the specimen having at first been determined, on the evidence of its lower jaw, as a *Hyperoodon.*

On July 19 of the present year a telegram was received from the Coastguard officer at Fethard, Co. Wexford, announcing the stranding of a Whale, said to be 19 feet long and to have two teeth at the extremity of the jaw. It was supposed that this animal would prove to be a Common Bottle-nosed Whale (*Hyperoodon rostratus*); but the lower jaw was asked for in order to render its determination certain. On the arrival of the jaw, the pair of large and massive teeth at its anterior end showed at once that the animal was not a Common Bottle-nosed Whale. and it was more than suspected that it would prove to be a *Ziphius cavirostris.* Mr. A. H. Bishop, one of the preparators of the Museum, was accordingly sent to Fethard; and he was fortunately in time to secure the remainder of the skeleton, as well as to make observations on its external characters and to prove that it was a male. By a happy coincidence the skeleton of the 1913 specimen already alluded to was at this time removed from the sand; and the characters of its skull proved beyond doubt that, like the Fethard specimen, it was a *Ziphius cavirostris.* The British Museum is thus in possession of two Irish skeletons (the Unionhall specimen not quite complete) of this interesting

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* For this method of cleaning skeletons, specially to be recommended for Cetacea, since it enables very large specimens to be dealt with without trouble, and moreover removes the oil from the bones, see R. F. Scharff, 'The Museums Journal,' x. 1911, p. 196.

Cetacean. When the skeleton of the Wexford specimen has been cleaned I hope to be able to publish a further account of these two animals, in conjunction with my friend Mr. W. P. Pycraft; but the records are interesting enough to justify the publication of a preliminary notice on the subject.

The Wexford specimen was stranded on July 18, 1915, at the entrance to Bannow Bay, on the east side of the point of land separating that Bay from Waterford Harbour; and it was alive when first observed. I am indebted to Mr. Dennis McCarthy, of H.M. Coastguard, for valuable information with regard to its appearance, as well as for the trouble he took in facilitating the acquisition of the specimen by the British Museum. In a written description sent after the despatch of the original telegram, Mr. McCarthy states that the lower jaw "was narrow and projected beyond the upper." The head was "mostly white in colour and along the upper part of the back as far as the fin with numerous whitish streaks running downwards in all directions; the remainder a darkish colour." This account is confirmed by Mr. Bishop, who made an excellent drawing of the animal, based on his photographs, measurements and notes, on his return to the Museum. This drawing represents the head, including the whole of the lower jaw, and part of the back as white in colour, the rest of the skin being black, or at least dark. The white colour extends over the whole of the head and part of the body, in front of an oblique line drawn from the anterior end of the dorsal fin, and passing in front of the pectoral fin, to the posterior end of the lower jaw. The colouring of this specimen is thus extremely similar to that of the New Zealand animal figured by von Haast (1880, pl. xxiii.). Much of the skin was covered by long, linear streaks, similar to those usually seen on the skin of *Grampus griseus*. According to the observations of Mr. Bishop, who did not see the specimen until July 23, when much of the epidermis had been lost, the streaks were arranged singly. In the specimen figured by von Haast the skin is said to have been marked with parallel, elongated streaks, in pairs, as well as with oval scars, each with two dots in the centre. These dots, and the two members of each pair of streaks were a constant distance apart, and were "evidently made by the teeth of other individuals of the same species."

One of the most striking features of the Wexford specimen was its possession of a pair of large and massive teeth, situated at the extreme end of the lower jaw, the left tooth being appreciably larger than its fellow. The exposed parts of these teeth are roughly conical, the teeth diverging from one another and being 20 mm. apart at their base. Other measurements of the exposed parts of the teeth are:—

	Right.	Left.
Antero-posterior diameter, at base...	32 mm.	36 mm.
Transverse diameter, at base	29	32
Length	34	42

The larger tooth thus has a diameter of nearly one and a half inches, while the part which projects beyond the gum exceeds one and three-fifths inches.

The teeth just described have a close resemblance to those of the specimen from the Chatham Islands, described and figured by Hector (1872, pl. v.) under the name of *Epiodon chathamensis*, now usually regarded as a synonym of *Z. cavirostris.* They are also precisely similar to those of a specimen, No. 21248, from Bering Island, described and figured by True (1910, p. 52, pl. xxii. fig. 4) and regarded by him (pp. 31, 35) as probably belonging to an adult male. It is important to notice that the Wexford specimen was definitely ascertained to be a male, from its characters in the flesh; and it thus confirms the accepted conclusion that the teeth of *Ziphius* are larger and more massive in the male than in the female. In the paper just cited (p. 54) True states his conclusion that adult males have "fusiform teeth with closed roots and a diameter of from 25 to 30 mm.," while in females they are "quite slender, with a diameter of from 10 to 14 mm."

The specimen* from Unionhall, Co. Cork, was stranded on Feb. 13, 1913; and it was described as much injured, being in an advanced state of decomposition, with most of its skin worn away. There are thus no observations to record with regard to its colour or sex. Its length is said to have been 20 feet. The lower jaw had a considerable resemblance to that of *Hyperoodon*; and, as there were no teeth piercing the gum, it was supposed that it belonged to that genus. The examination of the skull, two years later, at once corrected this mistake. The absence of the large maxillary crests which are so characteristic of *Hyperoodon* is alone sufficient to show that it cannot belong to that genus; while as features specially distinctive of *Ziphius* and possessed by this specimen, mention may be made of the peculiar form of the premaxillæ and the great difference between those of the two sides, as well as of the elongated nasals, separated from one another by a long suture. The length of the skull is about 3 feet 3 inches; the Shetland skull described by Turner (1912, p. 77) being 36½ inches long.

In his recent elaborate account of the cranial characters of *Z. cavirostris*, True (1910, p. 54) states his belief that the two sexes of this species are distinguishable from one another by certain well-marked cranial characters, in addition to those afforded by the teeth, as noted above. He admits, however, that the sex of some of the specimens from which his conclusions were drawn was not definitely known. The adult male was believed to be distinguishable by the great development of the "mesorostral ossification" (Turner) and by the presence of a deep "prenarial basin." In the adult female the mesorostral ossification is less developed, while the premaxillæ are narrow, and flat proximally (pp. 35, 36), and the prenarial basin is undeveloped. It appears to me that these conclusions are well founded; and applying them to the Unionhall specimen, there seems every reason to believe that it was a female. This conclusion is strengthened by the fact that the teeth of the apex of the lower jaw do not cut the gum, although the dissection made by Mr. Pycraft proved that they are present and of considerable size, projecting for about 25 mm. beyond the bone of the jaw and nearly reaching the surface of the gum, and having a basal diameter of about 13·5 mm. It should be added, however, that the Unionhall specimen was not fully adult, since the sutures of the skull are still extremely distinct, while the epiphyses of the vertebræ are not yet ankylosed to the centra.

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* For assistance in obtaining the skeleton of this specimen, the Museum is indebted to Mr. J. Phelan, of H.M. Coastguard, Unionhall.

It would be extremely desirable to be able to state characters by which a *Ziphius* in the flesh can be distinguished certainly from the other Ziphioid Whales; but I am not prepared to do this without further study of the subject. In the case of the males, in their adult condition and probably at earlier stages of their life, the occurrence of a pair of large teeth at the extreme front end of the lower jaw and cutting the gum is probably amply sufficient for recognition, particularly when taken in conjunction with the absence of the enormously swollen forehead so characteristic of the adult male *Hyperoodon*. But a young Ziphioid Whale of either sex, or an adult female which has no teeth visible during life, is less easily referred to its proper genus.

It has already been pointed out that the Wexford specimen of *Z. cavirostris* and von Haast's New Zealand specimen (1880, pl. xxiii.) were white above and dark below—a type of coloration which is by no means common in Cetacea. Other specimens which have been referred to this species were, however, dark above, even on the head, and light below. Making full allowance for the uncertainty which so often prevails with regard to the real colour of Whales, owing to *post mortem* changes and to the fact that the examination frequently has to be made some time after death and under unfavourable conditions, it must be concluded, in the present state of the evidence, that *Z. cavirostris* is a species of very variable coloration (*cf.* True, 1910, p. 35). It may further be noted that according to Van Beneden (1888, p. 60) the rostrum and forehead of *Hyperoodon* become white in colour with age. The projection of the lower jaw beyond the tip of the snout is apparently a positive character of *Ziphius*; and the snout is probably less distinctly marked than in either *Mesoplodon* or *Hyperoodon*.

A further difficulty in defining the external characters of *Z. cavirostris* arises from the uncertainty which prevails with regard to the two mandibular teeth in the female. In some of the published accounts of this sex, these teeth are described as visible during life; while in the Unionhall specimen (probably a female) they were completely concealed beneath the gum.

It is hardly necessary to attempt to give a full account of the literature of the subject in this preliminary paper, but it may be convenient to refer to the lists of recorded occurrences given by Turner (1872, p. 770), Flower (1872, p. 207), Van Beneden (1888, p. 86), and True (1910, p. 30); the Memoir last cited giving far the fullest account of the general characters of the species at present published, and being accompanied by excellent figures of skulls and other parts of the skeleton.

With regard to published figures of the entire animal it may be noted that some of the earlier representations are so different from one another that, in the absence of other evidence, it would be hard to believe that they all represented the same species. Attention may, however, be directed specially to the following published illustrations:—

A Spanish specimen figured by Cabrera (1914, p. 380), who records three specimens from Santander, Bay of Biscay;

Specimens respectively from Alaska and Newport, Rhode Island, of which photographs are reproduced by True (1910, pl. xli. figs. 3, 4).

It may be noted finally that whether all recent specimens of *Ziphius* are referable to a single species or not, there is every reason to believe that the Irish specimens belong to *Z. cavirostris*; a conclusion reached with regard to the Shetland skull by Sir William Turner. This species was named by Cuvier (1823, p. 352) on the evidence of a skull obtained from the Bouches-du-Rhone, at first regarded as a fossil specimen, but shown by later writers to have been really that of a recent animal.

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1912. **Turner, Sir W.**—"The Marine Mammals in the Anatomical Museum of the University of Edinburgh," p. 77.

39. Fauna of West Australia.—III. A new Nemertean, *Geonemertes dendyi*, sp. n., being the first recorded Land Nemertean from Western Australia. By W. J. Dakin, D.Sc., F.Z.S., Professor of Biology in the University of W. Australia.

[Received August 5, 1915: Read November 9, 1915.]

(Text-figure 1.)

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SYSTEMATIC: Page

Geonemertes dendyi, sp. n. 567
STRUCTURE 569

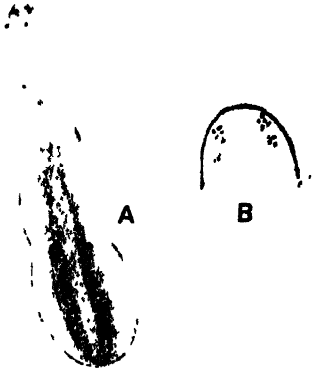
Land nemerteans are notoriously rare animals, and it is therefore particularly interesting to record a new species from the Western State of Australia. The record is interesting too, because the other known species in Australia comes from Victoria and New South Wales, about two thousand miles distant from this western locality. The country between can scarcely be called suitable for the distribution of such an organism. The animal was discovered by the author, whilst searching for *Peripatus*, in a valley in the Darling Range not far from Perth. Land nemerteans are cryptozoic in habit and occur in the same situations as *Peripatus* and land planarians, yet no specimens have previously been discovered in West Australia, although many scientists have made collections of these latter Cryptozoa. I, myself, have looked for *Peripatus* and land planarians in the Darling Ranges, and other parts of West Australia, on very many occasions without ever meeting with a specimen of *Geonemertes*. This first record does not indicate any greater abundance, for only one isolated individual—a mature female—was found. It is probable, however, that in the keen search for *Peripatus* (when the attention is concentrated on distinguishing this animal from its background) specimens of the nemertean have been passed over as land planarians. Such, in fact, would have been the case this time, if the animal had not protruded a long proboscis on being disturbed.

The example belongs to the genus *Geonemertes*, and I have much pleasure in naming the species after Professor Dendy, who was not only the first to discover land nemerteans in Australia and New Zealand, but who elucidated many points in the anatomy of the genus. The previously recorded species from Australia and New Zealand are *Geonemertes australiensis* Dendy, occurring in Victoria, New South Wales, and Tasmania; and *Geonemertes novæ-zealandiæ* Dendy, a very rare species occurring in South Island, New Zealand. The new form *G. dendyi* is more like *G. australiensis* than the New Zealand species.

Habitat.—The specimen was found under a small log in a rather damp situation, about two yards from a small stream, in one of the valleys near Armadale. Under the same log were two specimens of *Peripatus gilesii*, a slug, and some of the usual small cryptozoic arthropoda. *Scutigera* was also common in the neighbourhood.

External characters.—*Geonemertes dendyi* is apparently much smaller than the East Australian species, for its total length when living and uncontracted was only 15 mm. (proboscis retracted). The greatest breadth occurred at a point about one third of the length from the posterior end. Just in front of this was a slight constriction, as if the animal had been nipped. It is probable that this feature is only some temporary or individual character of the specimen captured, but as no others are to hand for purposes of comparison, it is worth mentioning.

Text-figure 1.



Geonemertes dendyi.

A. Dorsal view. B. Anterior end considerably enlarged.

The colour of the living animal is brown-pink, but the shade is not uniform over the entire surface. The lateral parts of the body are more of a light flesh-colour and signs of the large ova were visible, showing through the skin. The under surface is pale. On the dorsal surface, and most prominent on the posterior third of the animal, are two dark stripes of chocolate-brown. They are not sharply defined, and the dissecting-microscope indicated that they are collections of little brown spots. There is just a faint indication of the continuance of the stripes forward over the anterior part of the dorsal surface.

Close to the anterior end of the body, and on the dorsal surface, are the eye-spots. According to Dendy, *Geonemertes australiensis* differs from other known species of *Geonemertes* in the possession of a large number of eyes. The New Zealand species has only four eyes, and four or six are the usual numbers. In Dendy's specimens from the eastern states the eyes numbered as many as thirty or forty, and they were arranged in two groups. It is interesting to note that the author describes each group (containing about 20 eyes of various sizes) as sometimes showing indications of a division into an anterior and a posterior group, and he says that "it suggests that the numerous eyes of *G. australiensis* may have been derived by subdivision of four eyes, two large anterior and two small posterior, such as we find in *G. chalicophora*.'

In *Geonemertes dendyi* there are four quite distinct groups of eyes – two anterior groups of large eyes, and two posterior groups of smaller eye-spots. There are five or six spots in each of the anterior groups and three in each of the posterior, making a total of sixteen.

ANATOMY.

The anatomy of the animal as made out from serial sections does not differ in any points of importance from that of *G. australiensis*. Unfortunately, the animal was fixed in an acid fixative and consequently it is impossible to see anything of the calcareous stylets.

The epidermis and basement-membrane are both of the usual type. There are no rod-like bodies, and calcareous bodies like those described by Dendy in *G. australiensis* are not to be seen. This, however, is no proof of their absence, for Dendy was never able to find them in his sections although no acid fixative was employed.

Within the basement-membrane are two layers of muscle-fibres, but judging from the figures the thickness of the layers is not so great as in *G. australiensis*. The outer sheath is of circular fibres, the inner of longitudinal muscle-fibres. If a layer of diagonally disposed muscle fibres exists between these two sheaths, it is not evident in the transverse sections. The muscular diaphragm, described by Dendy as a development in the cephalic region, is well seen in the present species.

The alimentary canal exhibits no new points. In the specimen sectioned the lumen of the canal is almost obliterated by masses of protoplasm such as have been described by von Graff as occurring under certain conditions in *G. chalicophora*. The mouth opens into the rhynchodæum as in *G. australiensis* and the New Zealand species. The position of the opening is in front of the cerebral ganglia.

The Lateral Organs. -Two distinct cephalic or ciliated pits are to be found on the ventral surface near the anterior end of the body. The ducts pass almost vertically upwards toward the cerebral ganglia and then turn rather abruptly and run toward the sides of the body. Cilia can be traced in these ducts for a considerable distance—they are to be seen where the ducts are quite close to the ganglia. There is little to add further in connection with these, except that the ducts come into rather intimate connection with a curious mass of tissue lying ventrally and slightly posteriorly to the ventral lobes of the brain. This is probably what Dendy calls the "œsophageal organ." The tissue is most certainly non-nervous. It stains an intense blue with hæmatoxylin and has all the characters of glandular tissue.

Cephalic Gland.—One of the most curious differences between *G. dendyi* and *G. australiensis* is the apparent lack of a well-developed cephalic gland. I must confess that I cannot recognise any structures in my sections which seem to fit in with the description given by Dendy. The sections were stained with hæmatoxylin, and glandular structures are well brought out. The dorsal glands are well developed, and agree in position with those described as occurring in *G. australiensis*, but there are no other distinctly "large, irregular, glandular masses, closely packed together—staining deeply with hæmatoxylin" overlying the dorsal lobes of the cephalic ganglia. The only well-developed glandular structures in this position are the anterior glandular masses of the dorsal glands.

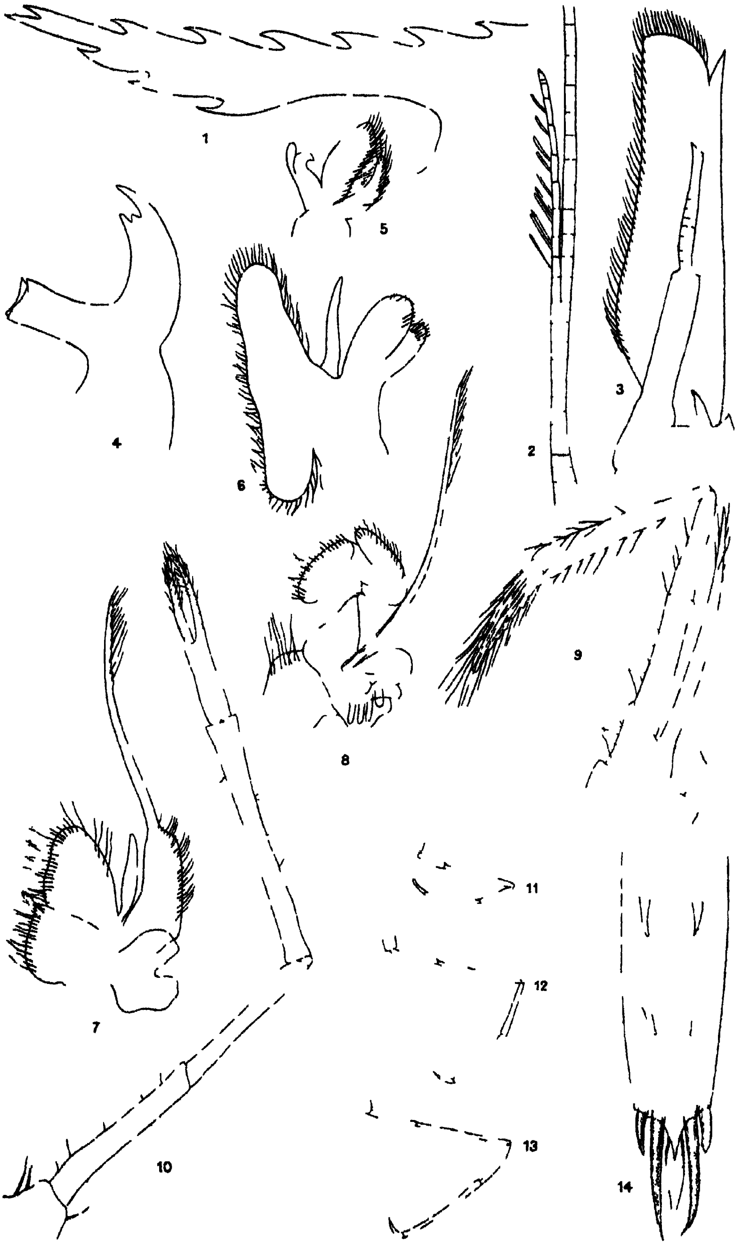
Reproductive Organs.—The single specimen so far known is a mature female, and there is no trace whatever of male organs. The sexes are also separate in *G. australiensis*. In the classification offered in Benham's treatise (Treatise on Zoology, Ed. by E. R. Lankester, Part iv.) the genus *Geonemertes* is placed in the family Prosorhocmidæ: "With four eyes, cerebral organs are rudimentary. Cephalic gland large. Mouth and rhynchocœl coincident. Usually hermaphrodite." If *G. dendyi* is considered as one member of this family, the diagnosis of the latter requires to be made a little more general.

In *G. dendyi* the ova are found throughout almost the entire length of the body—the most anterior ones occurring just posterior to the brain-masses. They are present in different stages of growth, but most of them are very large and apparently mature. Curiously enough, I cannot detect the genital ducts which are figured so distinctly by Dendy. In one or two places there are signs that might be interpreted as remains of these ducts. If one did not know, however, that such structures *did* exist in the genus, they would never be suspected from my sections.

SUMMARY

The characteristic features of *Geonemertes dendyi*, sp. n., are as follows. The length of the mature female is about 15 mm. when crawling. The colour is brown-pink, with two dorsal and somewhat posterior darker longitudinal bands of chocolate-brown. The eyes are arranged in four groups—two anterior, each of five or six larger spots, and two posterior groups, each of three smaller eyes, making about sixteen or seventeen altogether. Lateral organs are well developed, opening by characteristic ciliated cephalic pits on the ventral surface at the anterior end. The mouth opens into the rhynchodæum. The sexes are distinct. Cephalic gland apparently not well developed. Other structures agreeing well with the description of similar parts in *G. australiensis*. The specimen was found under a small log, together with *Peripatus gilesii*, in the Darling Hills, Western Australia, not far from Perth.

P. Z. S. 1915. DAKIN. Pl. 1.



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40. Fauna of West Australia.—IV. *Palæmonetes australis*, sp. n., being the first record of the genus in Australia. By W. J. Dakin, D.Sc., F.Z.S., Professor of Biology in the University of W. Australia.

[Received August 5, 1915: Read November 9, 1915.]

(Plate I.*)

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With the exception of the Phyllopoda and the crayfishes, few aquatic animals appear to have been collected and recorded from the fresh waters of Western Australia.

Among the so far unrecorded species is a prawn-like crustacean, which is extremely common in many of the rivers near Perth. What its actual range in the continent may be, remains to be discovered. The species was first found by the author in a tow-net which had been thrown at random from a river-bank and pulled back; the net just scraped the bottom on the way. About fifteen specimens were caught in this very short, careless haul, and as the animals are pretty active in their movements they must have been present in large numbers in the water.

Since the first discovery, specimens have been obtained from several other districts. All proved on investigation to belong to the genus *Palæmonetes*. This new record marks a considerable increase in the known geographical range of this genus. So far as I can determine, only one species of *Palæmonetes* is known to occur in Europe, but that is found in Sweden, Denmark, Belgium, France, Italy, Spain, and the Black Sea. It has also been collected in the British Islands and even so far south as Egypt. This species, *Palæmonetes varians*, lives in water that is more or less brackish and close to the sea, as well as in the perfectly fresh water of lakes and rivers.

Most of the known species of the genus *Palæmonetes* appear to be American—the following having being recorded. *Palæmonetes vulgaris* (sea-water—bays and estuaries of U.S.A. coast), *Palæmonetes exilipes* Stimpson (fresh-water—U.S.A.), *P. carolinus* Stimpson (marine—U.S.A. coast), *P. argentinus* Nobili (South America), *P. kadiakensis* Rathbun (North America), *P. calcis* Rathbun (blind species found in caves in Cuba), *P. antrorum* Benedict (blind species from an artesian well in Texas), *P. eigenmanni* Hay (blind species from caves in Cuba). The Rev. T. R. R. Stebbing writes me that he has described and figured a species from Natal, so that South Africa has also a representative of the genus. It is surprising to find that, on the whole, there are only slight differences between the Australian species and *P. varians* from Europe or the species known from the American continent.

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* For explanation of the Plate see p. 574.

Habitat in West Australia.—Specimens of *P. australis* were first met with at Northam, a small town inland on the plateau, about 70 miles from the coast and at an elevation of roughly 500 feet. They were captured in the River Avon, where it breaks up into small channels below the weir. The water is of course quite fresh. The largest specimens obtained have been caught at the above place, and the animal is quite plentiful at all seasons of the year. Large-sized specimens have also been captured in Gin Gin Brook, about 50 miles north of Perth and at an elevation of roughly 300 feet. Mr. W. B. Alexander, M.A., of the West Australian museum, has placed in my hands collections captured in Bibra Lake and the Serpentine River. The lake is a small expanse of water only a foot or so deep, if that in the dry season, and is situated on the coastal plain not so very far from the sea. The habitat of these lake specimens is very different from that of the Northam examples, and there is a characteristic difference in the size of the individuals, those from the Northam River being the larger. The average length of the individuals caught at Northam is 32 mm., against 20 mm. for the Bibra Lake type.

The Serpentine River is about 34 miles south of Perth, and the specimens were caught where the river leaves the hills and enters the coastal plain. The specimens from Northam are described and figured as the type specimens of *Palæmonetes australis.*

DESCRIPTION.

Body stout. Length of largest specimens 39 mm. from end of telson to tip of rostrum, and 72 mm. to tip of outstretched antennæ. The living animals are transparent, with a prevailing amber-green tint. Brown pigment flecks occur laterally on the posterior margins of the abdominal terga, and there are sometimes two delicate longitudinal lines on the carapace somewhat laterally situated. The carapace is not quite so long as the last three abdominal segments. The sixth abdominal segment is almost twice the length of the fifth.

Rostrum.—The rostrum is long and about equal in length to the carapace, but may be very slightly longer or shorter. The tip of the rostrum exceeds the distal margin of the antennal scales. The rostrum is laterally compressed and has a pronounced curvature trending upwards towards the apex. A few small chromatophores are present. The dorsal armament consists of usually five or six teeth which are almost equally spaced along the entire length of the rostrum. This is without counting a distal tooth which forms the upper portion of the bifid apex. The most posterior dorsal tooth is well behind the orbital notch, and the next one is immediately over it. There are three or four ventral teeth. The dorso-ventral thickness of the rostrum is not so great as that of *P. varians*.

Eyes.—The eyes are well developed and on fairly long stalks.

Antennules.—The antennules are as long as the abdomen with telson. The peduncle when extended does not attain the length of the rostrum by about one-third of the latter, and falls short of the distal margins of the antennal scales by about one-fifth the length of the scales. The shorter ramus of the outer antennule is fused to the longer for about half its length.

Antennæ.—The antennal scales are large, long, and broad, and more than twice the length of the antennal peduncle minus the first segment. They are not quite so wide distally as proximally. The antennal peduncle falls short of the first segment of the peduncle of the antennule.

Mandible.—The mandibles are without palps. Incisor and molar processes are well developed and tipped as indicated in the figure.

Maxillulæ and Maxillæ.—These appendages are as figured. They possess no features of systematic importance marking them off from the similar appendages of *P. varians*.

Maxillipedes.—These are similar in structure to those of *P. varians*. The third maxillipedes when extended reach approximately to the end of the antennary peduncle.

Peræopods. The second peræopods are the longest, and when extended they overlap the antennary scale by palms and fingers. The third peræopods are about as long as the first, the fourth a little longer, and the fifth pair are the longest of the posterior three. The first pair of peræopods attain almost the apex of the antennary scales when extended forwards. The chelæ of the second pair are shorter than the carpus, and the dactylus slightly more than two-fifths length of palm.

Telson.—The telson is longer than the preceding segment. It terminates in the mid-line with a spine. The armament consists of two pairs of stout spines and one pair of setæ. The latter are situated one on either side of the median spine. The posterior margin of the telson differs distinctly in shape from that of *P. varians*. Two pairs of spines are present on the dorsal surface of the telson.

CONCLUSION.

Palæmonetes australis occurs in the fresh-water of rivers some distance from the coast in West Australia, and is also found in shallow lakes on the coastal plain.

Females bearing eggs which have been just extruded have been captured in September (Bibra Lake), and others bearing embryos not far from the hatching stage have been collected on January 1st from Gin Gin Brook. This would indicate that the breeding season coincides with the early months of the summer—the dry season. Most of our West Australian fresh-water animals breed in the winter or spring, and many possess drought-resisting eggs. Unfortuately, newly hatched larvæ have not yet been captured, so that we are unable to figure this stage.

The species of *Palæmonetes* known at present differ but slightly from one another, and the characters of most importance systematically which mark the Australian species are (*a*) rostrum, (*b*) rami of antennule, (*c*) length of peræopods and their segments, (*d*) telson.

EXPLANATION OF THE PLATE.

Palæmonetes australis.

Fig. 1. Rostrum (form with seven dorsal spines). × 9.
2. Outer antennular flagellum (basal portion).
3. Antennal scale and base of antenna. × 8.
4. Mandible. × 20.
5. First maxilla. × 12.
6. Second maxilla. × 12
7 9. First, second, and third maxillipedes. × 12.
10. Second peræopod. × 7.
11 13. Third, fourth, and fifth peræopods. × 8.
14. Telson. × 12.

41. The Keeping and Breeding of Tasmanian Devils (*Sarcophilus harrisi*). By Mrs. MARY G. ROBERTS, C.M.Z.S., M.R.A.O.U.

[Received June 21, 1915: Read October 26, 1915.]

(Text-figure 1.)

PART I.

Until I was asked by Mr. A. S. Le Souef, Director of the Zoological Gardens, Moore Park, New South Wales, early in 1910 to obtain, if possible, Tasmanian Tigers (*Thylacinus cynocephalus*) and Devils (*Sarcophilus harrisi*) for the London Zoological Society, I had never thought of keeping either of these animals in my collection; in fact, they were quite unknown to me except as museum specimens, although I had frequently visited remote parts of our island. I have vivid recollections, however, of how, when a young child at boarding-school in the late forties, some of the girls from Bothwell, near the Lake District, used to give graphic and terrifying accounts of the Tasmanian Devils with their double row of teeth. This belief is not yet exploded, as it was impressed upon me lately with the utmost confidence by a country visitor that such was the case; he not only believed, but said "he had seen." The teeth have been described to me by a scientist as truncated.

Shortly after hearing from Mr. Le Souef, by means of advertising, writing, etc. I obtained three for the London Society, and having then become thoroughly interested I determined to keep some myself. Since that time a large number have passed through my hands, and more than once I have been "a woman possessed of seven devils."

In April 1911 I received a family (a mother and four young), and again in September of the same year a similar lot arrived. The former were very young, and I had the opportunity of watching their growth almost from their first appearance when partly protruding from the pouch. When sending them, the trapper wrote that "the mother was so quiet, I need not be afraid to pick her up in my arms." The little ones hung from her pouch (heads hidden in it), and she lay still and motionless as if afraid of hurting them by moving, and allowed me to stroke her head with my hand. However timid they may be, and undoubtedly they are extremely so, growling and showing their teeth when frightened, they always evince this gentleness and stillness when nursing little ones.

The skin of the young, on arrival, had the appearance of a slate-coloured kid glove, the tail darker towards the tip. The hair could be seen growing black and velvety from the head downwards, the latter being hidden in the pouch for some days, and it was interesting to note the progress of the growth of the hair from day to day. The shoulders were covered while the hind-quarters were almost, or quite, bare, although a faint streak of white was discernible where the white markings were to come later on. At this early stage, should the mother get up to move about, which she rarely does in the daytime, the young somehow scramble into the pouch again.

This family went later to the London Society, but the second, which came on the 16th of September, I kept for my own pleasure, with the exception of the mother; as she had lost a foot when being trapped, I thought it best to have her destroyed later on. Unfortunately, when they were about half grown one escaped into the garden, and the next morning her mutilated remains were found—she had fallen a victim to our two fox-terriers. The three survivors have been ever since an unfailing source of interest and amusement to my family, to visitors, and myself. When a bone or piece of meat was thrown to them a tug-of-war was always the result, and sometimes a chase into one door and out of the other of the little cave. At other times, while one has been holding on to a bone held in my hand, I have lifted it completely off the ground, while another would cling on round the waist and try to pull it down.

Many visitors from the Commonwealth have heard such exaggerated accounts of the ferocity and ugliness of the Tasmanian Devil (others, again, have believed it to be a myth), that they sometimes express surprise when they see them so lively, sprightly and excited, running out to my call; they then remark, "the devil is not so black as he is painted."

Two of these Devils were latterly kept together as a pair, and for the purposes of this article I will call them Billy and Truganini, after the last two survivors of our lost Tasmanian race. These showed no disposition to breed until April 1913, and my observation of them and of many others that I have had in my keeping is, that the disinclination to take up maternal duties is always on the part of the female. I then noticed suddenly a decided change—that Billy would not allow her to come out of their little den; if she did venture when called to be fed, or at other times, he immediately attacked her and would drag her back by the ear, or any other part, but although otherwise cruel, he would carry food in to her. When I called her, it was pitiable to hear her whining; but it was of no avail, for Billy was a relentless tyrant and kept her in strict seclusion for quite ten or twelve days; then early in May he allowed her to be free once more. From thence onward, although they were sometimes peaceable and affectionate, the balance of power was completely on Truganini's side; she constantly resented his approach by biting and snarling at him: it seemed as if coming events cast their shadows before, and she instinctively felt that he would do the young some injury. From now her pouch was anxiously scanned day by day, but it was some time before I could be sure that it was gradually enlarging. I had been advised by Dr. Hornaday, of the New York Zoological Park, that if ever the Tigers or Devils were likely to have young, to remove the male, and as soon as I was certain, I had Billy taken away

Text-figure 1.

Tasmanian Devils (*Sarcophilus harrisi*).

and placed with the other member of the family. This made Truganini most unhappy, as he was near enough for her to hear him, besides which, the two males fought; so, being cautioned by my family that perhaps my interference might cause a disaster, I yielded and replaced him, doing so with many misgivings. Matters went on much the same until late in September, when to my delight a tail, and at other times part of a small body, could be seen sticking out of the pouch, more especially when the mother sat up to wash her face, or rolled upon her back; unlike domestic cats, the devils use both paws for washing, placing them together and thus making a cup-like depression which, when thoroughly licked, is rubbed well over the face. Everything looked very promising on the Sunday before Michaelmas Day, when I noticed Truganini carrying large bunches of straw about in her mouth, evidently seeking for a retired place to make a bed, and we had already placed some fern logs in a corner of their yard. As Billy would follow her about and interfere, I had a box put down with a hole cut in the side that she might hide under; but it was of no use, as where she went he would also go, and a scrimmage was the inevitable result. Early next morning, with many misgivings I left home for ten days, only to find on my return that her pouch was empty and that the young had disappeared, and as no remains whatever had been found, I could only conclude that they had been eaten by Billy.

Thus ended all my hopes and anticipations for 1913. I have not so far related an incident that took place just before the breeding-season. Being hopeful that Truganini might have young in her pouch, and my assistant being as usual very busy, Professor T. T. Flynn, of the Tasmanian University, who is always interested in our marsupials, kindly offered to examine her pouch. As soon as an attempt was made to catch her, Billy grasped the position of affairs and fought to defend her with all his might, even getting behind her in the little cave, putting a paw on each shoulder and holding her tightly, lest she might get into what appeared to him to be the danger zone. By dint of perseverance and a little strategy he was outwitted at last, but our hopes were doomed to disappointment.

Truganini has now passed through another period of retirement, and I am hoping to record shortly a greater measure of success for 1914.

I cannot close this article without a few words in defence of the Tasmanian Devil, as I am sure that it is more or less "misunderstood," and the article with photograph published in the 'Royal Magazine' for October 1913 under the name of L. R. Brightwell, F.Z.S., is, I consider, greatly exaggerated both as regards their appearance and character, viz., "They are well named, for they tear everything, even sheep, to pieces if they get the chance."

On several occasions when one of mine has escaped, the only mischief done has been the destruction of a fowl or a duck or two. It would have been just as easy for a wallaby to have been killed if they had had the inclination, about which our fox-terriers would not have hesitated for a minute if a chance had occurred. When in transit to London last year one escaped, and I have been told by the chief officer of the vessel that "the passengers were much alarmed as there were children on board, and someone went about with a revolver." Later I came across the butcher who was in charge at the time, and he appeared to have been rather amused than otherwise, and told me the missing one was discovered at last quietly sleeping under the berth of one of the sailors! I don't wonder, with the reputation that the devils have, that the passengers were alarmed.

Part II.

Having written so much in the first part about the keeping and breeding of Tasmanian Devils, I fear I have not many fresh facts to relate for 1914. The season arrived a month earlier, and Billy released his little mate from retirement on the 20th of March. She was just as disagreeable to him afterwards as she had been on the former occasion, biting and snarling whenever he approached her, and on the 8th of July I removed him from the enclosure. There was nothing of importance to note until the 30th of the month, when a little tail was seen sticking out of the pouch, and on the following day a foot and thigh were visible.

I will now give my observations on certain days following. August 3rd—Little ones partly hanging out of pouch. I must not forget to state that about this time, or a little later, Truga was observed carrying bundles of straw about in her mouth, with which to make her bed, and finally took them behind the fern logs that we had thrown down, but unfortunately I omitted to note the exact date. 4th, 5th, and 6th--Sometimes saw three tails only. 7th -A little one lying on its back, feet in air and head in pouch. On the 9th, for the first time, the man saw one standing alone on a fern log, when it immediately scrambled down to the mother. 10th, 11th, and 12th--Mother frequently seen, sometimes with only three tails observable, at other times little ones exposed, bodies resting on the ground with the heads hidden. From these observations, I may point out how difficult it is to know exactly when the young are able to leave the pouch, it being coincident, I think, with the making of the bed by the mother. On the morning of the 13th Truga ran out to meet me, jumping over fern logs, and left a little one whining behind, having the tails of the other two and a foot showing outside the pouch; she went back at once to the young one, when it immediately got on her back. 14th—Mother came out with two dangling from her, leaving a little one behind crying; she at once ran back and returned with all three in her pouch. Next day when she came forward to meet me, only two tails and a foot could be seen. 16th—All three were hanging out, and instead of jumping over ferns as usual, she had scraped away the straw and earth and came out from an opening underneath them. By this time they were getting quite covered with hair, white markings distinct, and sometimes when disturbed they would make a faint attempt at a bark. From the 19th to the 23rd inclusive they were occasionally seen all together out, yet on the three days following I saw her about with two dangling from her. On the evening of the 27th, upon her running out to meet me, I threw her some meat, which she carried in to the young, afterwards returning for more for them, and eventually lay down contentedly in front of the opening. 29th—All three playing like puppies, biting each other and pulling one another about by the ears. 30th—Whole family hanging from the mother as she ran out, and one hardly knows which to admire most, her patience and endurance, or the hardihood of the young in holding on and submitting to so much knocking about. The whole process seems very casual and most remarkable, when compared with the breeding and rearing of other marsupials. With the Kangaroo and allied types the head is seen first, looking out of the pouch, and in the early stages is quite bare. Sept. 1st—Young ones playing in their little corner. 9th—Not been seen this month in their mother's pouch. 30th—Coming out all alone for pieces of meat and evidently able to look after themselves. At the beginning of the New Year I removed them to other quarters and replaced Billy, much to the annoyance of Truga; probably she resented the loss of her little ones, and showed her anger by biting him severely about the body and leaving various tooth-marks.

From observations made during the two seasons, I have come to the conclusion that about four months and a half elapse between the breeding-season and the time the young are able to leave the pouch.

The baby devils had the sense of smell very strongly developed; immediately I approached, their nostrils would begin to work and a vigorous sniffing would go on. They were also expert climbers, and although I had some specially constructed yards made, they would get up the wire-netting and walk along the top rail quite easily; at other times they would climb a pear-tree growing in their enclosure and sit in the branches like cats.

General Remarks.

I have always found devils rather fond of a bath; quite recently, going down to their yard after an illness and finding only a drinking vessel, I ordered a larger one to be put in, and they showed their pleasure by going in at once, sometimes two at a time. I have occasionally poured water from a can over them, when they would run to and fro under it with much enjoyment.

Their sight in daylight is rather defective; they seem to pick up their food more readily by smelling than by seeing, and I think they can see objects better at a distance.

At the present time I have six running together, my own three and three that I bought when in their mother's pouch. All are tame, frolicsome, and lively. I can go in and have a bit of fun with them, and when I am outside their enclosure they frequently climb the wire-netting to the height of nearly six feet, and get their little black faces close to mine with evident delight. We have tried more than once to get them photographed, but it is impossible to keep them quiet, they are on for a scamper all the time. Recently an adult escaped, and it was discovered by a passing school-boy sitting on a high fence bordering the street, under the shade of some elm-trees, many people passing on the foot-path without observing it. They are, however, always very timid when coming down.

They are fond of the sun, and look well when basking in it, the rays shining through make their ears appear a bright red, fore feet parallel with the head, hind-quarters quite flat on the ground and turned out at right angles, somewhat as a frog.

My sympathy with my little black "brothers and sisters" is intense, probably evoked by having suffered much mentally owing to the gross cruelties which have come under my notice, the result of capturing them in traps. Frequently three or four have been sent to me in a crate, only to find later on one with a foot shot off or a broken leg. In a consignment received some time ago, a dead one was found: it bore unmistakable signs of a snare previously, round the neck, one foot was gone (an old injury), and finally a recently smashed leg much swollen, the cause of death. I communicated with the S. P. C. A., and since then have had none from that district.

I have derived much pleasure from studying the habits and disposition of the Tasmanian Devils, and have found that they respond to kindness, and certainly show affection and pleasure when I approach them. I have been led to believe that no case of their breeding in captivity has been recorded, and certainly not in Tasmania.

Others who do not know or understand them may think of them as they like, but I, who love them, and have had considerable experience in keeping most of our marsupials, from the Thylacine down to the Opossum Mouse (*Dromica nana*), will always regard them as first favourites, my little black playmates.

42. Notes on the Feeding of Snakes in Captivity. By E. G. Boulenger, F.Z.S., Curator of Reptiles.

[Received October 8, 1915 : Read October 26, 1915.]

Some years ago, in a paper contributed to the 'Proceedings' of the Society by Dr. Chalmers Mitchell and Mr. R. I. Pocock, entitled "The Feeding of Reptiles in Captivity" (P. Z. S. 1907, p. 785), a general account was given of the feeding habits of the Snakes then living in the Gardens, together with records of a large number of individual specimens, showing the amount consumed between the months of May and October. My own general observations tally with those of Dr. Mitchell and Mr. Pocock, and my object in presenting this paper is to lay before the Society some additional facts, to show how unnecessary it is to feed the snakes on live creatures, and to give a detailed record of the amount taken and of the regularity of the meals in a number of specimens over a period of a year.

Previous to my appointment at the Gardens I had fed the few snakes kept by me on live animals, being under the influence of the popular belief either that many snakes would not take dead food at all, or that, at any rate, in most cases much time had to be spent in inducing them to do so. On taking over the charge of the reptiles here, I confess I was surprised to find how readily they accepted dead prey. I was nevertheless of opinion that some individuals would not accept dead food under any circumstances, and I therefore asked and obtained the Secretary's permission to offer live food in certain cases where dead had been persistently refused. From the summer of 1911 up to that of 1915, living prey was offered to nine snakes that had refused the dead as food. The results given below are, I think, convincing, showing that, with possible rare exceptions, a snake that refuses to feed on dead animals is not more likely to accept these if alive.

1. Anaconda (*Eunectes murinus*).

This snake, a large specimen, 16 feet in length, refused dead food for the first eight months of its captivity. A live duck was offered on two occasions in the course of the first fortnight of the 9th month, but was refused on both. The third week it was once more given dead food, and this was accepted. It has since fed with the greatest regularity on dead chickens and ducks, consuming on an average one a fortnight.

2. Reticulated Python (*Python reticulatus*).

This, a very large snake measuring 24 ft., had fed since its arrival in 1898 with some regularity on dead kids and ducks. In August 1911 it broke its jaw in the process of swallowing a kid. The jaw was set in plaster of Paris, and the setting was removed a month later. After the accident it refused to feed, and in November it was decided to tempt it with something alive. Live ducks were offered on two occasions in November, but were not taken. In the first week of December it was once more given dead food—a duck, which was immediately accepted. The snake unfortunately died a few weeks later.

3. COMMON BOA (*Boa constrictor*).

This snake, measuring 7 ft., was presented to the Society in July 1912. It had been kept in captivity some time before its arrival here, and been fed on live food only. For the first two months of its captivity at the Gardens it was offered dead rats, rabbits, and pigeons, all of which were refused. As it had previously fed well on live animals it was, in September and October, offered such, but they were not taken. In November dead food was again offered and this time accepted, the snake feeding henceforth with some regularity up to June 1913, when pneumonia caused its death.

4. SOUTH-AFRICAN HOUSE-SNAKE (*Boodon infernalis*).

This snake had been kept by me for two years previous to my taking over the charge of the reptiles here. It had been fed on live mice. On its transference to our Gardens it at once took dead food.

5. PUFF ADDER (*Bitis arietans*).

Received in June 1911, this snake fed with some regularity on dead rats up to the end of December. For the first six months of 1912, however, it refused food, and as it was getting thin we decided in June of that year to let it have live food. Live rats were accepted during part of June, July, and August, and part of September. Towards the end of the latter month, dead food was substituted and taken, the snake feeding on dead rats to within a week of its death in January 1914.

6. BUSHMASTER (*Lachesis mutus*).

This snake was presented to the Society in December 1912. As I had been informed by Mr. Mole, of Trinidad, who had experience of this species, that it had never been induced to take dead prey, after offering it dead rats for three consecutive weeks, I obtained the permission to give it live food. The live rats were, however, likewise rejected, and the snake died in March of starvation.

7. BUSHMASTER (*Lachesis mutus*).

This specimen, received in April 1913, was likewise offered living animals after refusing dead food for some weeks. It also refused to feed at all, and died in September.

8. Crossed Viper (*Lachesis alternatus*).

This snake, received in April 1914, was offered living food after having refused dead prey for fifteen months. The live mice were accepted, but unfortunately the snake died shortly after its

9. Texas Rattlesnake (*Crotalus atrox*).

The snake, acquired in June 1909, fed from time to time upon dead animals up to June 1911. Having refused food from then up to September, and as it was becoming emaciated, in the first week of September it was offered live rats, which were refused. The following week it fed on three dead mice. From that day to its death in January 1912 it refused all food whether live or dead.

10. Texas Rattlesnake (*Crotalus atrox*).

As this snake, which was received in May 1912, refused dead food for the first six weeks of its captivity, it was decided to give it living animals, and it was offered live rats during the month of July. It, however, refused both the live and the dead food, and died in September.

Although a number of persons with much experience in keeping these reptiles in captivity, have been unsuccessful in inducing their specimens to accept dead prey, the above records, I think, prove that, in our Gardens, at least, it is quite unnecessary to give any snakes live food, as out of about 300 snakes kept here during the period covering these observations, with the exception of the Crossed Viper which died shortly after its meal, not a single snake would feed on live animals only, and in four cases dead food was accepted after the live prey had been refused.

A point greatly in favour of giving dead animals to the snakes lies in the possibility of examining the former for tubercle. Up to the month of June 1910 the animals intended for the snakes were not examined. At the suggestion, however, of Professor Plimmer, the Society's Pathologist, from that date onwards the food has been carefully inspected and about 5 per cent. condemned, with the result that tubercle in snakes which prior to June 1910, accounted for 14 per cent. of the deaths, has been reduced to just over 3 per cent. In the years 1908, 1909, and the first half of 1910, before the inauguration of the new system, 33 snakes in all died of tubercle, while since the examination of the food, *i. e.* the second half of 1910, and the years 1911, 1912, 1913, 1914, and the first half of 1915, there have been 23 cases only.

It is generally believed that if snakes will take dead animals these have to be quite freshly killed and warm. Such is, however, not the case, for, as has been pointed out by Dr. Chalmers Mitchell and Mr. Pocock, the prey is frequently not taken until long after it has been introduced into the cages.

As an instance of this, it is, I think, worth recording that one of our large Indian Pythons on one occasion did not take a rabbit which had been given it at 4 o'clock on a winter's afternoon, until 9 o'clock next morning, when, as was only to be expected after 17 hours in a temperature of nearly 80°, it was in an almost putrid condition.

Another point of peculiar interest is that while tame rats are acceptable to a large number of the snakes, wild rats are seldom taken, and even when accepted are not digested but brought up again a few days later. That this should be the case with rats caught outside the Gardens is understandable, but the wild rats I refer to are those caught in the Gardens and are therefore, living as they do on the remnants of the food provided for the exhibits, comparatively clean feeders.

The experience of Mr. H. N. Ridley who, writing of the pythons in the Botanical Gardens in Singapore, stated that small specimens fed about once a month, large ones once in six to nine months, did not coincide with that of Dr. Mitchell and Mr. Pocock, who recorded the fact that the majority of specimens fed with the greatest regularity during the summer months, some only refusing food when about to shed their skins. As may be seen below, my experience with the large snakes likewise differs from that of Mr. Ridley: two large specimens feeding on as many as thirty occasions during the year, the longest period of fasting amounting to just over a month; while of the smaller specimens it will be noted that a Boa which did not fast for a longer period than three weeks, fed on thirty-five occasions in the course of a year.

The table on p. 587 gives a detailed record of the feeding of a number of healthy specimens over a period of one year.

Name.	*No. of Times Fed.*	*Longest Period of Fast.*	*Total Amount taken.*
Reticulated Python (*Python reticulatus*) (22 ft.)	30	5 weeks.	16 kids, 17 ducks.
„ „ „ „ (17 ft.)	26	4 „	30 chickens, 3 ducks, 1 rabbit.
„ „ „ „ (14 ft.)	32	4 „	31 ducks, 8 pigeons, 3 rabbits.
Indian Python (*Python molurus*) (12 ft.)	20	6 „	15 pigeons, 14 rabbits.
„ „ „ „ (8 ft.)	13	13 „	13 pigeons, 1 large rat.
African Python (*Python sebæ*) (6 ft.)	29	6 „	1 pigeon, 92 rats, 6 sparrows.
Anaconda (*Eunectes murinus*) (16 ft.)	24	4 „	24 chickens.
Common Boa (*Boa constrictor*) (9 ft.)	35	3 „	23 rabbits, 13 pigeons, 2 large rats.
„ „ „ „ (8 ft.)	14	9 „	11 pigeons, 8 rabbits, 3 large rats.
„ „ „ „ (4 ft.)	17	7 „	33 large rats.
Indian Burrowing Boa (*Eryx johni*)	15	8 „	30 small rats.
Mole Snake (*Pseudaspis cana*)	36	3 „	38 rats.
*Malay Water-Snake (*Acrochordus javanicus*)	25		84 small fish.
*Indian River-Snake (*Tropidonotus piscator*)	40		200 small fish.
*Sharp-nosed Snake (*Lioheterodon madagascariensis*)	40		120 rats.
*False Mocassin (*Tropidonotus fasciatus*)	40		160 frogs.
Indian Rat-Snake (*Zamenis mucosus*)	23	4 „	39 rats.
Corais Snake (*Coluber corais*)	21	5 „	76 rats.
Chicken Snake (*Coluber obsoletus*)	18	7 „	21 mice, 6 sparrows.
Four-lined Snake (*Coluber quatuorlineatus*)	15	6 „	27 mice.
Bull Snake (*Coluber melanoleucus*)	37	4 „	139 rats.
Smooth Snake (*Coronella lævis*)	5	16 „	5 lizards.
*King Snake (*Coronella getula*)	40		160 mice.
*Indian Cobra (*Naia tripudians*)	30		90 mice.
Black and White Cobra (*Naia melanoleuca*)	41	2 „	33 small rats, 147 mice, 2 sparrows.
Black-collared Cobra (*Naia nigricollis*)	36	3 „	51 small rats, 58 mice, 8 sparrows.
Night Adder (*Causus rhombeatus*)	14	2 „	203 small frogs.
Russell's Viper (*Vipera russelli*)	19	4 „	32 small rats.
Gaboon Viper (*Bitis gabonica*) (5 ft.)	9	12 „	9 pigeons.
„ „ „ „ (2 ft.)	16	7 „	10 rats, 8 sparrows.
Puff Adder (*Bitis arietans*)	32	7 „	111 rats.
Green Viper (*Atheris chlorechis*)	10	11 „	20 small frogs, 2 lizards.
Fer-de-Lance (*Lachesis lanceolatus*)	14	9 „	22 rats.

* In the above a number of specimens were kept together in the same cage, and it was impossible to give exact individual records. Only an average has therefore been given.

43. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

[Received October 1, 1915; Read October 26, 1915.]

(Text-figures 1–6.)

XVIII. ON *TÆNIA STRUTHIONIS* (PARONA) AND ALLIED FORMS.

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I have in my possession a considerable number of examples of a Cestode from the Ostrich *Struthio masaicus*, which are either identical with *Tænia struthionis* of Parona[*], or belong to a closely allied species. The description given by Parona is not quite sufficient to enable the identity of his species and mine to be established beyond doubt. But it is at least clear, as I shall point out presently, by comparing the facts of structure one by one, that the species described by Parona and that to be described here by myself are not to be referred to the species described under the same specific name by v. Linstow[†].

Although the details given by Parona are scanty, they are quite sufficient in my opinion to forbid any confusion between his species and that more fully dealt with by v. Linstow. My chief reasons for regarding them as two distinct species are the following. In the first place, v. Linstow's Cestode was obtained from *Struthio molybdophanes*; I infer that Parona obtained his worms from *Struthio camelus*. The scolex of *Tænia struthionis* of v. Linstow is only 1·18 mm. broad, while the species described by Parona has a stouter scolex of 2 mm. diameter[‡].

"Ein eigentliche Rostellum ist nicht vorhanden"—says v. Linstow of his species, while that described by Parona has, according to his figure, a quite strong rostellum. Correlated with this would appear to be the feebler character of the rostellar hooks in the worm from *Struthio molybdophanes*. The width of the proglottids in the two forms also appears to differ greatly; in the Tæniid described by v. Linstow, the diameter is but 4 mm.; while in Parona's specimens the same measurement was from 8 to 9 mm., *i. e.* quite double that of the first-named variety. This seems, like the other feature mentioned in this brief account of differences, to be hard to reconcile with specific identity. The account given by Parona of internal structure is so slight that the comparison cannot be pursued further.

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[*] Ann. Mus. Civ. Genova, (2a) ii. 1885, p. 425.

[†] Arch. Mikr. Anat. xliii. 1893, p. 147.

[‡] But see the observations of Zalluff quoted later (on p. 591) which tend to reduce the importance of this apparent difference, but do not affect what follows in the above *résumé*.

A question of nomenclature thus arises. The name *Tænia struthionis* first occurs in Rudolphi's "Synopsis"[*], it is there a *nomen nudum*, but given on the authority of Houttuyn in Müller's edition of Linnæus[†]. In the earlier work of Rudolphi[‡] the same worm (I presume) is named *Tænia struthiocameli*, and is also a *nomen nudum*, and again referred to Houttuyn in Müller's Linnæus[§]. I am indebted to Mr. C. Davies Sherborn for kindly informing me that Houttuyn himself[‖] does not refer to the ostrich at all in his work, though Tænias are mentioned. It is thus erroneous to term the species *Tænia struthionis* or *Tænia struthiocameli* Houttuyn.

In Müller's work there is no name given at all; the occurrence of a *Tænia* in the ostrich being merely mentioned. Thus if a *nomen nudum* has any claim at all to be admitted, the species is to be referred to Rudolphi and is to be called *Tænia struthiocameli*, since the earlier of the two works by that author which mention the species calls it by that name. Diesing[¶], however, quoting both Müller and Rudolphi's two works, terms the species *Tænia struthionis*, but again as a *nomen nudum*. The earliest actual description therefore of a *Tænia* from *Struthio* is that of Parona already referred to. We may perhaps safely accept his name, since it is accompanied by a description though not a conclusive one. I shall have to return again to this matter in considering the species to which it seems necessary to refer the worms which I now describe.

The *scolex* of the worm which forms the subject of the present communication is a little over 1 mm. in breadth in the two or three examples in which I measured it. The region of greatest breadth is opposite to the suckers; but the breadth was not increased by the extrusion of the latter. The suckers lay within the contour of the scolex. It is clear therefore that this species has a less robust scolex than Parona's *Tænia struthionis*. But while the actual measurements of the scolex of my species agree more with those of the worms described by v. Linstow as *Tænia struthionis*, my species shows a scolex with a well-developed rostellum, thus disagreeing with v. Linstow's worms and so far agreeing with that described by Parona. This is very evident from the figure given by Parona[**], where the hardly extruded rostellum is plainly exhibited. Parona does not state the number of hooks present on the rostellum; v. Linstow gives the number found by himself as 180. I find in my species something between 120 and 130. These hooks are, as in other *Davainea*, of the well-known hammer-shape so characteristic of the family Davaineidæ.

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[*] Entoz. Syn. Mant. 1819, p. 173.

[†] Linné's Naturgeschichte von P. L. S. Müller, Th. vi. Bd. ii. p. 904.

[‡] Entoz. Hist. Nat. 1810, p. 209.

[§] It is to be noted that the initials of Müller are as stated here. He is referred to as "St. Müller" by Rudolphi, and "H. Müller" by Diesing.

[‖] Natuurlyke Historie, vol. i. pt. 14, 1770.

[¶] Systema Helminthum. i. 1850, p. 555.

[**] Parona, *loc. cit.* pl. vi. fig. 2.

The hooks really form two concentric rows, which arrangement is only clear in sections which pass through the "handle" part of the hook; that they are of different sizes is only shown in the "head" of the hammer, where one series is much shorter than the other; I could find no such difference in thickness in the "handle" region of the hooks. An alternation between larger and smaller hooks is stated by Parona to occur in his species. The hooks are of course implanted upon the edge of the circular rostellum. They are of the usual golden-brown colour. Von Linstow has represented the hooks of his examples, called by him *Tænia struthionis*, as being weak and frayed out at the point of implantation. I have found nothing of the kind in the robust (though small) hooks of the examples examined by myself.

My own observations are in fact more in accord with those of a later investigator than those referred to. Dr. Zilluff*, referring only to v. Linstow's paper and not to that of Parona, naturally finds differences to record ("naturally" if I am correct in thinking that v. Linstow's specimens are of another species than that which Parona and I describe). He emphasizes the rostellum and gives the diameter of the scolex as 1·33 mm., the dimensions agreeing with mine rather than with Parona's. But this author does not mention from what species of *Struthio* he obtained the material.

The *suckers* are not armed, as is the case in certain other members of the genus, a great part of the species of which have armed suckers. I believe that I can state this fact positively. Excepting where the retractor muscles are attached to the suckers, the latter lie for the most part free within the cavity of the scolex to which they are fitted. A space is generally visible between sucker and body-wall. Although there is no apparent difference that I could detect between the individual suckers, I have noted in this worm a means of distinguishing the dorsal from the ventral couple. The two dorsal vessels, instead of ending in the medullary region like the ventral vessels of the water-vascular system, bend dorsally, each of them perforating the layer of longitudinal muscles of the cortex ends in the neighbourhood of one of the suckers. The exact mode of ending I did not ascertain. It is therefore possible to distinguish two of the suckers as belonging to the dorsal surface. The characters of the musculature of the scolex I shall deal with later in connection with the general arrangement of the muscles of the body.

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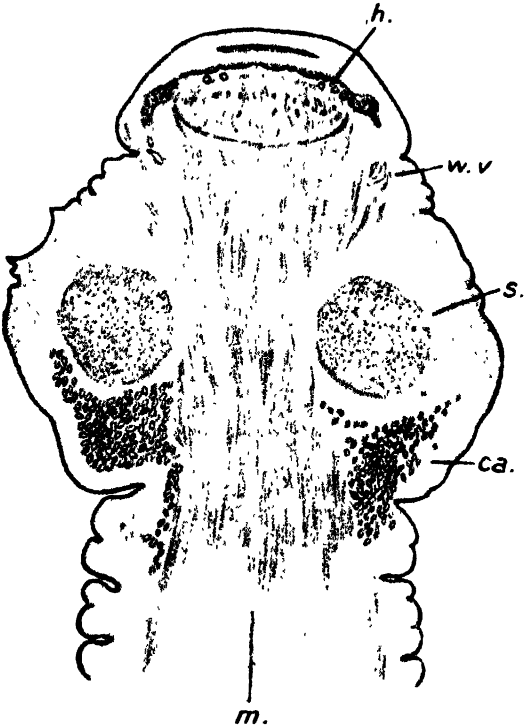
* "Vergleichende Studien uber die Muskulatur des Skolex der Cestoden." Inaug.-Diss. Univ. Zurich, 1912. (Published also in Arch. f. Naturg. of the same year.) See also Lühe in Zool. Anz. xvii. 1894. p. 280.

Von Linstow particularly mentions that in the species studied by himself, the anterior part of the body is devoid of calcareous bodies. In the specimens which I have examined by sections, the calcareous bodies are peculiarly numerous anteriorly, and especially in the scolex, where they form in parts closely aggregated masses as is shown in the accompanying sketch (text-fig. 1).

Text-figure 1.



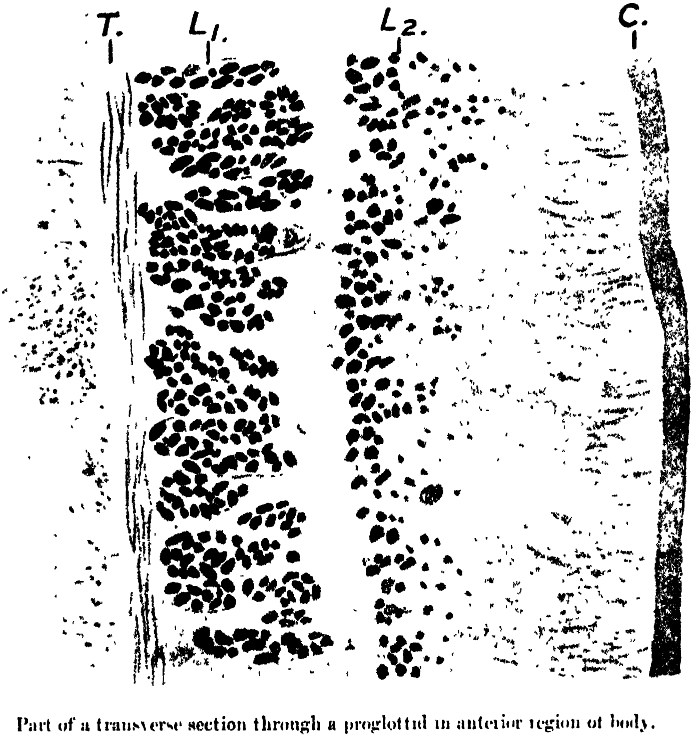
Longitudinal section through scolex.

ca. Calcareous bodies. *h.* Hooks seen in transverse section through "root." *m.* Muscles of rostellum ending above in rostellum. *s.* Sucker. *w.v.* Water-vascular tubes.

I need not describe their distribution in the scolex exactly, for they occur everywhere between the outer skin and the suckers and rostellum, except, however, among the muscle-fibres of the longitudinal muscular layer. Further back in the neck region the medulla is largely occupied by masses of calcareous bodies which are generally speaking very abundant in this species, so much so that I should be inclined to add the abundance of these bodies to any definition of the species. This is another reason for refusing to accept the identity of the worms from *Struthio masaicus* with those from *Struthio molybdophanes*.

The general shape of the body of this worm is as figured by Parona. The anterior region of the body is slender; it is much wider posteriorly, but not by any means so wide as in the species described by Parona. I found 5 mm. to be the greatest diameter of the posterior proglottids. They are overlapping, and as a rule so contracted as to be much wider than long. In a few cases the proglottids were, however, more expanded, but were never actually longer than broad. The worms reach a length of perhaps nine or ten inches.

Text-figure 2.



Part of a transverse section through a proglottid in anterior region of body.

C. Cuticle. L_1 & L_2. Layers of longitudinal muscles. T. Transverse muscles.

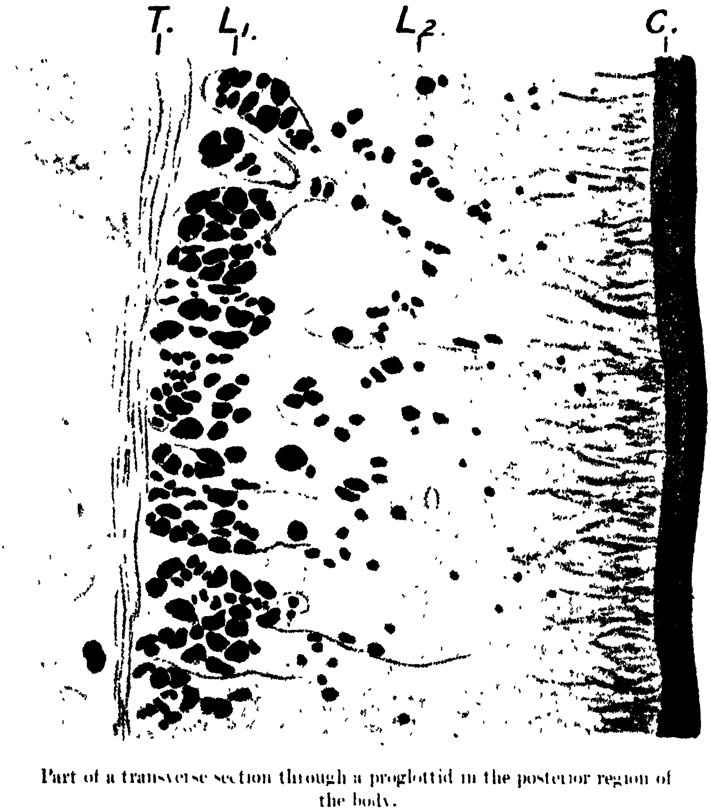
The cortical layer is deep, the diameter being greater than that of the medullary layer. This is particularly marked in the anterior segments, where the reproductive organs are only just beginning to appear. The *longitudinal muscle-layer* presents definite characters in the arrangement of its fibres, as is general among Cestodes. It is not usual to find accurate figures of the course of these fibres, which are constantly of systematic importance. I therefore attempt to reproduce here such accurate drawings.

At the base of the rostellum the longitudinal muscles lie in a continuous circular layer, in which form they are implanted upon the rostellum. A little further back, at the level of the suckers, the layer of muscles is markedly divided up into separate bundles which are of different sizes. There are 12 or 13 of these separate bundles which are more or less completely separated. In the neck, which immediately follows upon the scolex, the bundles cease to exist as separate structures except at the two sides opposite to the water-vascular tubes. The unsegmented or neck region in this worm is very short and, as in the other examples ascribed to the species *Tænia struthionis vel T. struthio-cameli*, it may fairly be remarked that a neck can hardly be said to be present. Further back—but still in the anterior region of the body, where the gonads and their ducts are still only recognizable as a mass of condensed nuclei—the longitudinal muscular layer has more or less acquired its definitive arrangement. It is here (text-fig. 2) divisible into two quite distinct sheets. That nearest to the medulla consists of a row of bundles each consisting of a good number of individual fibres which are packed close together and separated by vertical fibres forming a dividing palisade. Above this is a very distinct space dividing the lower layer from the upper. This space is formed of ground-tissue, and there is no trace therein that I could discover of transverse muscle-fibres. On the outer side of this space is a layer of smaller bundles, *i. e.* each bundle consisting of comparatively few fibres, and above this again, without any marked interval, a certain number of single muscle-fibres, which complex reaches some way towards the subcuticular layer. Inside the whole longitudinal layer of muscles is a thin layer of transverse fibres separating these in the usual way from the medulla. Further back in the body the same arrangement exists, but it is not so clear cut as anteriorly. That is to say, the two layers of the longitudinal sheet are quite recognizable, but they are not so markedly divided from each other. This is shown in text-fig. 3.

Besides the sheets of muscle mentioned so far, the worm has, like most other Cestodes, a dorso-ventral system. I have already spoken of dorso-ventral fibres running between the bundles of the longitudinal coat. In addition to these the medulla is traversed by single fibres which cross it at right angles to its long diameter, and are numerous, dividing the medulla into quite narrow segments when seen in transverse sections.

The *water-vascular tubes* of this worm present no remarkable characters. The much larger ventral vessel is alone present in the posterior segments. Anteriorly both tubes are visible and superposed. The transverse trunks unite the ventrals in each segment. The usual valvular flaps in the ventral vessel are obvious and attached, as is usual (but not universal), to the inner wall of that tube.

Text-figure 3.



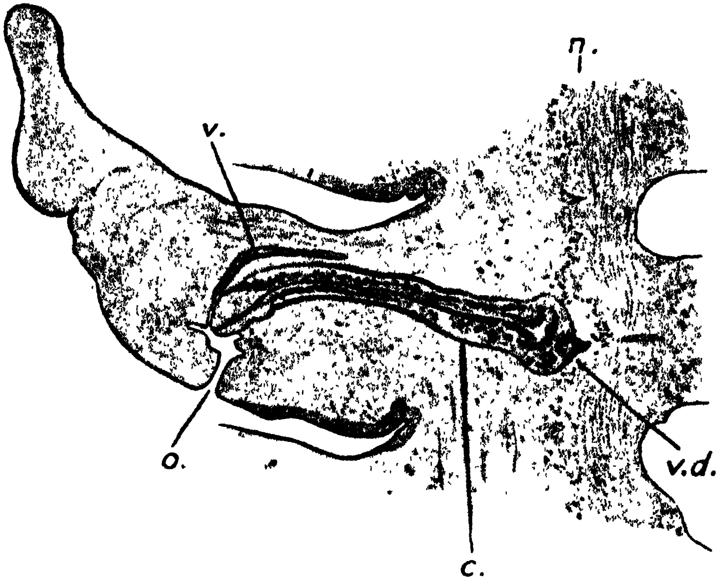
Part of a transverse section through a proglottid in the posterior region of the body.

Lettering as in text-fig. 2.

The *male and female efferent ducts* open into a cloaca genitalis which is not specially deep. The genital pores are completely unilateral in this species, and somewhat anterior in position, at any rate in front of the middle line of the lateral border. I have found so many orifices in succession opening on to one side of the body, that I cannot believe that the conditions are for instance as in *Chapmania tauricollis*, where the orifices really are alternate, though many open successively on to one side. All the pores that I found were on the same side of the body.

The *cirrus-sac* is comparatively short *, as in many species of *Davainea*, but not in all. It only just reaches the nerve-cord. It opens into the cloaca genitalis in front of and to one side of the vagina. The exact shape of the cirrus-sac has been carefully described in many Cestodes by many writers, and thus specific distinctions have been partly based upon its characters. The cirrus-sac of the present species shows that care must be taken in such descriptions. For I find considerable differences between the cirrus-sac in different segments, a state of affairs to be accounted for no doubt by varying contraction of its muscular walls.

Text-figure 4.



Longitudinal section through cirrus-sac (*c.*).

n. Nerve-cord. *o.* Orifice of genital cloaca. *v.* Vagina. *v.d.* Vas deferens.

More usually perhaps the cirrus-sac has the appearance represented in text-figure 4, which is drawn from a horizontal section through a more anterior segment. The cirrus-sac opens directly into the cloaca genitalis, and is of the same character and of pretty well the same diameter throughout. The walls are muscular but not thick; nor are they thicker in one region than in another. The vas deferens perforates the muscular coat at the extremity of the sac fairly exactly in the middle line, and is

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* In extended proglottids the cirrus-sac lies obliquely, being directed forwards.

coiled within the sac. The cirrus, with which it is continuous, appears to run a straight course and not to be coiled, since it is shorter than the cirrus-sac. In some posterior segments the cirrus-sac presented a different appearance. The peripheral and greater part of the cirrus-sac is thicker-walled than a terminal rather spherical and wider region into which opens the vas deferens.

The cirrus-sac is ensheathed externally by a layer of rather large nucleated hyaline cells, a not unusual character.

Did these two forms of the cirrus-sac occur in different individuals, one would be tempted to see in them a specific difference.

The *vas deferens* presents an extensive coil after it issues from the cirrus-sac. This occupies quite one-third of the diameter of the segment when the latter is stretched laterally. The coils are at least mainly dorso-ventral in direction, since in horizontal sections the sperm duct appears as a series of circular transversely cut areas.

The *vagina* has a straight or at most slightly sinuous course back to rather beyond the water-vascular tube -this section being thick-walled with a narrow lumen as in so many other Cestodes. A little way to the inside of the water-vascular tube the vagina narrows into an excessively fine bore, though with equally thick muscular walls at first. This slender region is coiled on the horizontal plane. It opens into the receptaculum seminis, which is rather pear-shaped. This and the succeeding portion of the vagina is not thick-walled but has a wider lumen, less of course in the case of the vagina. Although the proglottids, in which the vagina and its subdivisions had the characters that have just been mentioned, were not fully mature, at any rate as far as concerns the testes and sperm-duct, the receptaculum contained spermatozoa. It is necessary to point out that there is nothing to be specially remarked upon in the structure of the female efferent duct, which is constructed upon the plan usual in tapeworms. It is important, however, to be accurate, since there are minor differences to be noted which affect even the different species of *Davainea*.

Without attempting any general *résumé* for comparative purposes, I may direct attention to one or two species which differ from that now under consideration in these matters. In *D. sphecotheridis* of Johnston * there is apparently no distinct receptaculum seminis at all. In *D. corvina* Fuhrmann † the position of the receptaculum is different, beginning as it does to the outside of the water-vascular tube. In *D. polycalceola* ‡ the small receptaculum is close to the ovary. It is of further importance to note the age of the proglottid when giving the characters of the vaginal complex. The above description of that of "*Davainea struthionis*" relates to not fully mature proglottids. In fully mature proglottids the conditions observable are a little changed.

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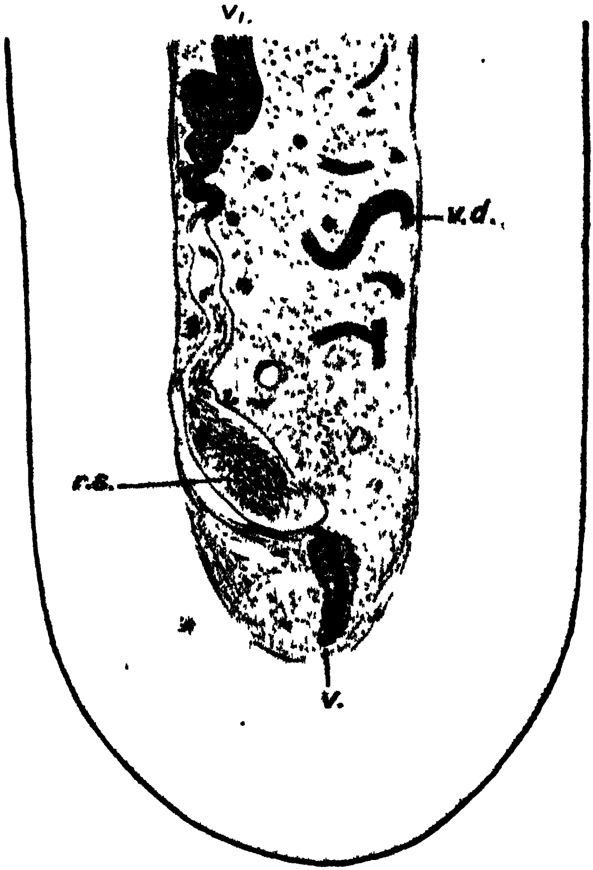
* T. Harvey Johnston, "Second Report on the Cestoda and Acanthocephala collected in Greenland." Ann. Trop. Med. Parasit. iii. 1914, p. 107.

† Abh. Senck. Nat. Ges. xxxiv. 1911, p. 252, fig. 3.

‡ v. Janicki, "Ueber zwei neue Arten .... *Davainea*," Arch. de Parasit. vi. 1902, p. 265, fig. 5.

The female duct (see text-fig. 5) from the receptaculum seminis

Text-figure 5.

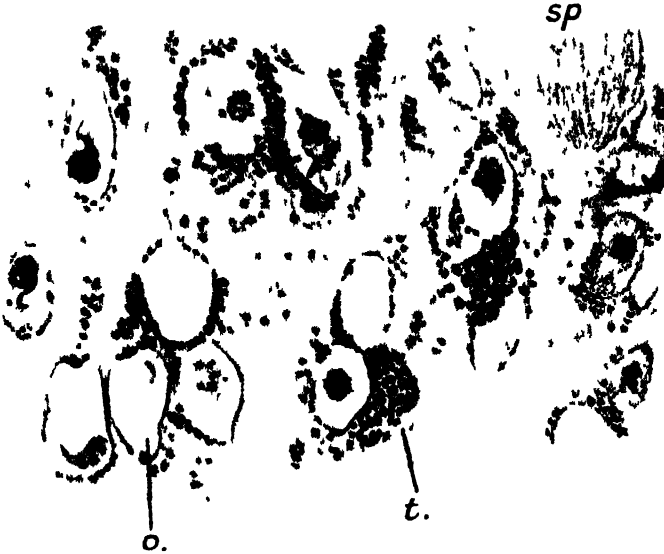


Part of transverse section through nearly ripe proglottid

r.s. Receptaculum seminis. *v*, *v*₁ Proximal and distal ends of vagina
v.d. Vas deferens.

to its median end is gorged with sperm, and thus presents the appearance of an elongated receptaculum such as that referred to above in *Davainea corvina*. And, moreover, there is this further resemblance, that the vagina is pressed by its increasing contents up to the margin of the water vascular tube, occasionally crumpling up the latter before it. Nevertheless, the more dilated region is still distinguishable as the true receptaculum seminis. It is evident, therefore, that the differences apparently shown between species in the vagina must be handled with care. I may add that in fully mature proglottids the vagina appears to be continued onwards beyond its junction with the other tubes of the female system. This may be merely a burst, though in some cases it has a tubular character. It is here, I assume, that fertilization occurs.

Text figure 6.



Ripe ova enclosed in capsules.

o. Capsule containing ovum. *sp.* Part of vagina gorged with sperm. *t.* Remains of a testes closely adpressed to an egg capsule, the nuclei in the walls of which are represented.

The *uterus* in the genus *Davainea* is never a conspicuous structure and never, when it exists, does it persist long. It is, however, too much to say, as does Ransom*, that "a definite functional uterus is not developed." For in *D. aruensis* Fuhrmann† has described a uterus with a lining of cells and containing ripe ova, which uterus, however, rapidly disappears. The same appears to be the case with *D. microscolecina* and *D. corvina*,

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* 'The Tænioid Cestodes of North American Birds.' Bull. U.S. Nat. Mus. No. 69, 1909, p. 14.

† Nova Guinea, vol. ix, Zoologie, Livr. 3, p. 169.

where the same author* remarks upon the rarity of observations upon the uterus of this genus. I find in the species with which I am here concerned very definite beginnings of a uterus, in which, however, I have not seen a large and continuous cavity. This consists in horizontal sections through proglottids, which are not fully mature but in which nevertheless the receptacula seminis are full of sperm, of a wide stretch of condensed medullary tissue. This structure appears to me to be exactly like the commencing uterus of some other Cestodes†. It lies in front of the ovary and shell-gland, but behind the receptaculum seminis and vas deferens, occupying thus about the width of the segment. It extends to a considerable distance right and left. The string of tissue representing the uterus is mainly to be differentiated from the surrounding medulla by its crowded nuclei. It is not solid but contains numerous cavities of various sizes. Some of these were filled with cells which may well be egg-cells. These cavities are at least frequently of the same size and shape as the oval interstices of the medullary meshwork. Later the proglottids (see text-fig. 6) are full of embryos each in its own separate cavity.

The following assemblage of characters are perhaps sufficient to define this species, to which I shall be unable to give a name with absolute certainty that it requires a new one. It will be better therefore to leave this matter unsettled for the present.

Definition of DAVAINEA SP. *parasitic in* Struthio masaicus.

Length 10-14 *inches; greatest diameter of proglottids* 5 *mm. Scolex* 1·2 *mm. diameter, with double row of* 130 *hooks in all: suckers unarmed. Scolex and anterior part of the body abound with calcareous corpuscles, which also occur posteriorly. No neck present. Segments of body not longer than broad; ripe segments not moniliform. Genital pores unilateral. Cirrus-sac reaching to nerve-cord. Dorsal water-vessel absent from posterior region of body. Ova imbedded singly in parenchyma extending into cortex.*

The above will be sufficient pending a revision of the genus to place the species approximately.

GENERAL REMARKS.

It is pretty clear from the foregoing observations upon the external characters and internal structure of this Cestode from *Struthio masaicus*, that it is certainly not to be confounded with the species named by v. Linstow *Davainea struthionis*, and which

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* "Vogelcestoden der Aru-Inseln." Abh. Senck. Nat. Ges. xxxiv. 1911, p. 254, & fig. 4, p. 252.

† *Cf. e. g.* Beddard in the instance of *Chapmania tauricollis*, P. Z. S. 1915 p. 434, text-fig. 3.

is a parasite of another subspecies of *Struthio*, viz. *S. molybdophanes*. While the general dimensions and the relative size of the scolex seem to be much the same in v. Linstow's species and in my own, there are several salient features in which they disagree markedly. The scolex of v. Linstow's worm has no rostellum, in the species examined by myself the rostellum is strong: v. Linstow's species has no calcareous bodies in the scolex, while my species is peculiarly well provided with these bodies: whatever may be the interpretation of the "ovaries" of v. Linstow in the posterior segments of his species, whether they are really a divided uterus or paruterine bodies, that Cestode clearly differs from mine where the embryos are scattered each one in a cavity of its own: finally, if v. Linstow's representation of the cirrus-sac and the vagina opening quite separately prove correct, there is here a great difference from my species, where the relations between these ducts is quite normal. These facts are, as I think, sufficient to show that there can be no identity between the two Cestodes of *Struthio masaicus* and *Struthio molybdophanes* *.

On the other hand, an exact comparison of my species with that termed *Tænia struthionis* by Parona is more difficult. If we can trust as differential characters the diameter of the proglottids and the size of the scolex, then the two forms are different. There are no other data that seem to permit of a more definite expression of opinion.

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* I have suggested (P. Z. S. 1915, p. 130) that v. Linstow's species may be actually referable to the genus *Chapmania*.

44. Some Notes upon the Anatomy of *Rana tigrina*. By GEO. E. NICHOLLS, D.Sc., late Professor of Biology, Agra College, India *.

[Received October 9, 1915 : Read November 9, 1915.

(Text-figures 1–3.)

In several skeletal and other characters, *Rana tigrina*—the so-called Bull-frog of India differs markedly from our common European grass or water frogs (*R. temporaria*, *R. esculenta*). These two frogs, which resemble one another fairly closely, appear to be the only species of which a detailed description has been given, and figures of one or the other alone appear in text-books all the world over. For the Indian form these figures are in some respects quite misleading, and since this frog is now generally used throughout India as a laboratory type, it has seemed desirable that attention should be called to those features in which *R. tigrina* differs from its European congeners.

1. *The Vertebral Column.*

In correspondence, doubtless, with the much larger size of this frog, the vertebræ are distinctly more stoutly built than is the case in *R. temporaria*. The neural arches are, relatively, greatly developed antero-posteriorly. Thus, when viewed from above, the vertebral column of this species does *not* show a series of gaps between the arches such as is so clearly seen in *R. temporaria* (*cf.* Howes, '**02**, fig. 35). On the contrary, there is, in *R. tigrina*, a very marked overlap of each arch dorsally upon that immediately posterior to it, and accordingly, when the vertebræ are in position (text-fig. 1), the centra are not visible from above.

Such a condition as this is said to be *imbricate*, and to characterize the Discoglossidæ and Pelobatidæ (Boulenger, '**97**, p. 38). Concerning the European species of Ranidæ, Boulenger points out that precisely the opposite condition prevails. His statement may be quoted:—"The neural arch is either closed above . . . or notched between the zygapophyses so as to expose the spinal cord between every two vertebræ; the latter type is most marked in *Rana*, in which, the lateral openings for the exit of the spinal nerves being also of large size, the vertebral column forms an open-work above and on the sides."

While this "open-work" vertebral column is seen typically in the European Ranidæ, it is also found in most of the other Anura, so that Boulenger notes this as one of the characters which separate the Bufonidæ and Hylidæ from the more generalized Arcifera. In this imbricate condition of the vertebral column it would appear, then, that *Rana tigrina* has retained (or reverted to) a somewhat primitive condition.

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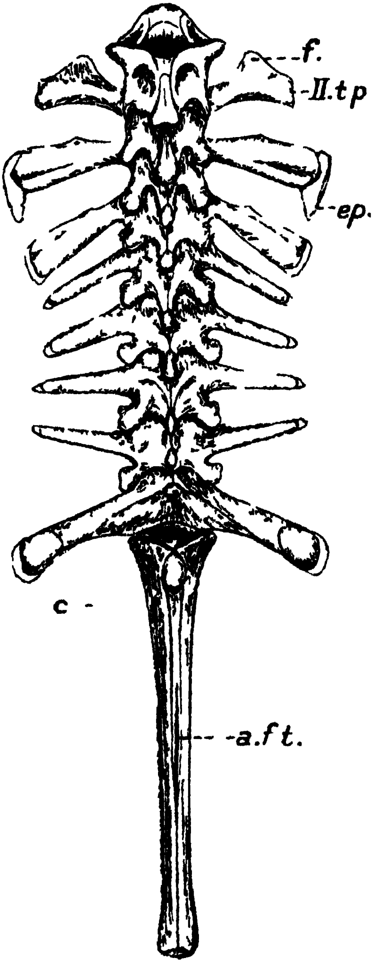
* Communicated by Prof. ARTHUR DENDY, D.Sc., F.R.S., F.Z.S.

Text-figure 1.



The vertebral column of *Rana tigrina*, as seen from above. × $\frac{3}{2}$.

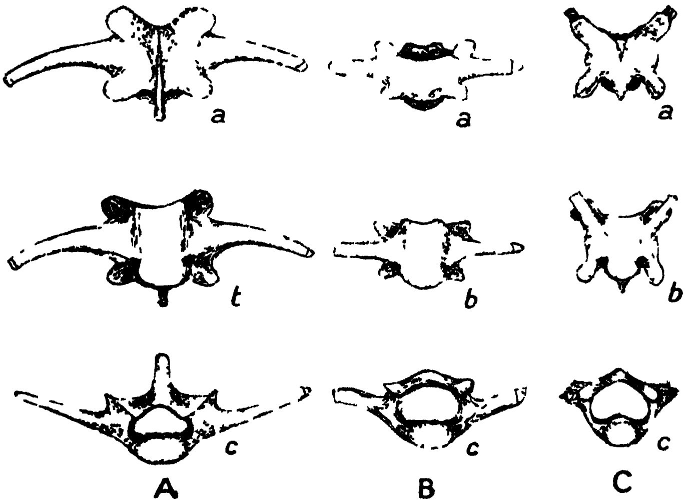
a.f.t., aperture for *filum terminale*; *c.*, coccyx; *ep.*, epiphysis; *f.*, flange upon the transverse process of the second vertebra, *II.t.p.*

It does not seem, however, that the occurrence of gaps between the neural arches in *R. temporaria* is to be attributed simply to a notching of the arches between the zygapophyses.

A comparison of the neural arch of a typical (*e. g.* sixth) vertebra of the grass-frog with that of the corresponding vertebra of *R. tigrina* or of *Pelobates fuscus*, will, I think, bear out this statement (text-fig. 2, A–C).

In all three cases it will be seen that there is an incisure upon the anterior face of the neural arch between the zygapophyses. In the Bull-frog and in *Pelobates* this incisure is a deep one, whereas in *R. temporaria* it is broad but comparatively shallow. Upon its posterior border the arch is practically not incised at all in *R. temporaria*, and is most deeply notched in *Pelobates*, the condition of *R. tigrina* being intermediate in this respect.

Text-figure 2.



The sixth vertebra of (A) *Rana tigrina* (× ¾). (B) *R. temporaria*, and (C) *Pelobates fuscus* (both × 3), to show the relative degree of incisure of the neural arches and the development of the neural spines in the three species. (*a*) Dorsal, (*b*) ventral, and (*c*) posterior view.

In *Pelobates* and in *R. tigrina*, however, *the centrum has practically the same length as the neural arch*, whereas in *R. temporaria* the centrum is, approximately, half as long again as the neural arch. When the vertebræ are articulated in the normal manner, therefore, the neural arches do not come into contact in this species, excepting at the zygapophyses, notwithstanding that some of the surplus length of the centrum has been absorbed in the concavity of the following centrum. In the case of *R. tigrina* (and *Pelobates*) the neural arch is sufficiently long to allow of considerable overlap upon the succeeding neural arch.

Neural spines, too, are well developed (text-figs. 1, 2). This is especially marked in the anterior vertebræ of the column, where the hinder end of a neural spine may extend backwards upon the ensuing vertebra almost to the level of the notch between its post-zygapophyses (*cf.* text-fig. 1). Posteriorly the spines become shorter, though still well developed. Thus, upon the seventh vertebra the neural spine extends but little beyond the posterior margin of the neural arch; in the eighth it is nearly vertical, and in the ninth the spine is slightly forwardly directed, so that its apex approaches very closely to that of the preceding vertebra. In this development of neural spines *R. tigrina* is remarkable, for of European Anura Boulenger has remarked: "Neural spines are absent or represented by a low keel, which is much prolonged posteriorly in *Discoglossus* and *Pelobates*" (op. cit. p. 38).

The intervertebral foramina in the Indian Bull-frog are, relatively, considerably smaller than are the corresponding nerve-exits in *R. temporaria*, and the column has, therefore, not at all the open-work structure which is so characteristic of our European frogs.

Moreover, the cartilaginous epiphyses found upon the distal ends of the transverse processes are particularly noticeable in *R. tigrina*. Upon the third vertebra (*cf.* text fig. 1) these are very large indeed, and backwardly directed, recalling strongly the condition figured by Boulenger for *Pelobates fuscus* (op. cit. fig. 75).

The transverse processes also are, relatively, much longer than are the corresponding structures in *R. temporaria*, but in this respect the condition of *R. esculenta* is closer to that of the Indian species.

Apart from these generalities, there are notable differences to be observed in the second, eighth, and ninth vertebræ of the two species.

In the second vertebra of *R. tigrina* there is developed a very pronounced flange-like projection upon the anterior border of the transverse process (text-fig. 1, *f.*). This varies somewhat in size, but becomes very marked indeed in some specimens. It serves, apparently, for the attachment of the *Mm. intertransversarii capitis*, which have their insertion upon the base of the skull, slightly lateral to the condyles. The complete absence of this flange from the European Ranidæ is doubtless to be attributed to the much slighter development of these muscles in these more slightly built frogs.

In the eighth vertebra, the transverse processes are as long as, and rather stouter than, the diapophyses of the three preceding vertebræ. They are peculiar, in the normal vertebral column of *R. tigrina*, in that alone of all the transverse processes they are sloped slightly forwardly (*conf.* Howes, '02, fig. 35, with my text-fig. 1). The well-developed neural spine rises almost vertically.

In the ninth vertebra, the transverse processes should be described as slightly conical (with the base of the cone distal) rather than as cylindrical, which latter shape is said to be characteristic of these structures in the Ranidæ. In some specimens I have observed a flattening even of the distal extremity of the diapophysis, which, too, is sometimes to be noticed in the immature *Rana temporaria.* The neural spine is somewhat variably developed, but is always represented by at least a slight elevation in the mid-dorsal line. From this a pair of distinct ridges diverge. These pass outwards and backwards onto the dorso-posterior face of the transverse processes, but fade out before reaching the distal end.

The coccyx, too, in *R. tigrina* differs from that of *R. temporaria* or of *R. esculenta* in that the paired foramina which, in these European species, permit of the exit of the tenth pair of spinal nerves are very frequently absent from the Indian species. When, however, they do occur, they are generally very minute indeed, and not uncommonly, upon one side or both, this external opening leads only into a blindly ending canal. As an infrequent variation, specimens are seen in which there may be two apertures upon one side. In such cases only the upper canal appears to have open communication with the vertebral canal. Such a condition is figured in my account of the Anuran coccyx ('**15**, fig. 1 *b*, x., xi.).

It is probable that we have here the last vestige of an aperture for the lost eleventh spinal nerve, such as is still found occasionally in the more primitive Anura.

From the foramen of the tenth nerve, when present, there runs backwards and upwards a slight groove which is often several millimetres in length.

Of a total of 32 coccyges examined, only four (12½ per cent.) showed *a pair of canals* for spinal x., and, of these, the openings in three were very small. In five other specimens a pair of extremely minute external apertures were found, but on neither side of three of these was there a clear passage for the finest hair. The remaining *two* permitted the passage of a very fine hair on one side only.

In *seven* other specimens a single aperture only was found, but in only two cases was I able to pass a hair into the vertebral canal. In the remaining five specimens the canal apparently ended blindly internally.

Thirteen coccyges (40 per cent.), including four specimens in which the vertebral column was abnormal in other ways, showed a complete absence of the foramina on both sides.

Three specimens exhibited two minute apertures on one side and a single aperture only upon the other. Of these, in one specimen all the canals ended blindly, and of the remaining two each had a single canal on that side upon which there were two apertures.

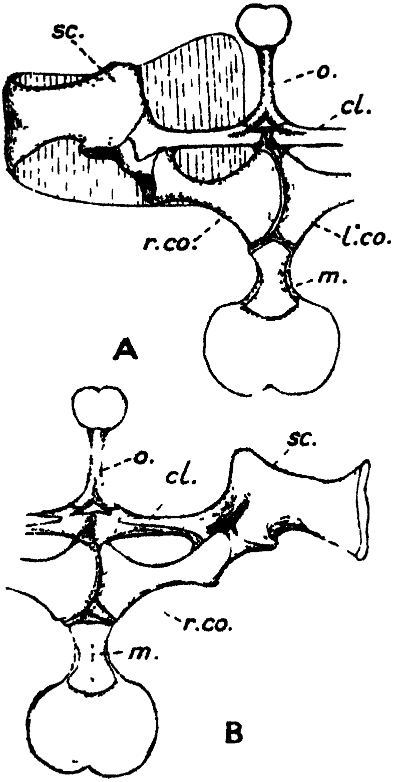
In the twelve asymmetrical cases the canal (or aperture) occurred in eight cases upon the right side and in four upon the left.

It is a little difficult to decide what is to be regarded as the normal condition of the coccyx in *R. tigrina.* It is probably correct to say that in the great majority of the individuals of this species, the paired foramina for the tenth spinal nerves are absent or imperfect.

The Shoulder-Girdle and Sternum.

The shoulder-girdle of *R. tigrina* (text-fig. 3) is very stoutly built and, in general, resembles the condition of the corresponding structure in *R. esculenta.*

Text-figure 3.



The Shoulder-girdle and Sternum of *Rana tigrina* (nat. size).

(A) Ventral view, and (B) dorsal view. In the latter the supra-scapula is removed upon the right side.

cl., clavicle; *m.*, metasternum; *o.*, omosternum; *r.co.*, *l.co.*, right and left coracoids; *sc.*, scapula.

In one particular, however, viz., in the arrangement of the coracoids, it presents a condition which has not, I believe, been recorded in any of the Firmisternia.

The coracoids, while having the normal shape and transverse position, *do not meet in a median epicoracoidal cartilage but overlap each other in the middle line.* At first sight it appears that there is merely an uneven suture, such as is seen between the epicoracoid cartilages of an immature *Rana temporaria*, but a closer examination reveals the existence of a definite overlap (*cf.* text-fig. 3).

It differs from the overlap of the arciferous condition in that the epicoracoidal cartilage is completely calcified in the adult and that the coracoid comes, at its antero-mesial border, into contact with the clavicle upon the ventral surface. There is, I believe, synostosis between the two coracoids, for there appears to be no freedom of movement.

The direction of the overlap, in the specimen figured, resembles that prevailing in the Arcifera, the right coracoid lying ventral to the left, but the opposite condition is met with not infrequently *.

Dorsally the pre-coracoid cartilage is seen. It appears to be calcified, and separates, somewhat widely, the clavicle from the coracoid.

The bony style of the omosternum is also peculiar (amongst Ranidæ) in being bifid posteriorly. The diverging processes meet corresponding elevations upon the clavicles, and the small space between the three bones is filled, in life, by a delicate membrane.

The Tenth Spinal Nerve.

Correlated with the minute size, or the absence, of the foramina in the coccyx, the tenth pair of spinal nerves are, in *Rana tigrina*, either extremely delicate or, more often, altogether absent. When present, they seem invariably to pass dorsally from their exits, lying in that small groove in the coccyx, to which reference has been made. In this disposition, therefore, this nerve differs considerably from the corresponding structure in *R. temporaria*, in which it passes ventrally after leaving its foramen. In the Bull-frog the nerve, even if present, is hidden from view in a dissection made, in the usual manner, from the ventral surface. It never, in this species, I believe, makes any contribution to the sciatic plexus, nor have I been able to demonstrate any sympathetic ganglion related to it.

Literature.

'11. Beddard, F. E.—"Contributions to the Anatomy of the Anura." Proc. Zool. Soc. 1911, p. 393.

'97. Boulenger, G. A.—The Tailless Batrachians of Europe. Vol. I. Ray Society. 1897.

'02. Howes, G. B.—An Atlas of Zootomy. London, 1902.

'15. Nicholls, G. E.—"A Note on the Urostyle (*Os Coccygeum*) of the Anurous Amphibia." Proc. Zool. Soc. 1915, p. 239.

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* Beddard ('11, p. 396) has pointed out that variation in this arrangement is also occasionally encountered in *Megalophrys feæ*.

45. A List of the Snakes of East Africa, North of the Zambesi and South of the Soudan and Somaliland, and of Nyassaland. By G. A. Boulenger, F.R.S., F.Z.S.*

Received October 4, 1915. Read November 23, 1915.]

(Text figures 1–3.)

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GEOGRAPHICAL: Page
East Africa, List of Snakes 611
SYSTEMATIC:
Keys to the identification of the Snakes of East Africa 611

This list is the third of a series published in these 'Proceedings'†, and the reader is referred to the first for an explanation of the method and scope of this aid to the identification of African Snakes. It is convenient to reproduce here text-figures 1 & 2 from the first paper, as a glossary to the terms used in the keys to the genera and species.

Synopsis of the Families.

I. Worm-like, with small inferior mouth, eyes hidden or visible under the head-shields, and body covered with uniform imbricate scales above and beneath.

18 scales or more round middle of body; ocular not bordering the mouth; tail not or but little longer than broad	TYPHLOPIDÆ.
14 scales round middle of body	GLAUCONIIDÆ.

II. Mouth large, eyes exposed; body with enlarged shields beneath (except in the marine genus *Hydrus*).

Ventral shields much narrower than the body; supraocular, if distinct, broken up into two or more shields	BOIDÆ.
Ventral shields at least nearly as broad as the body; supraocular single; poison-fangs, if present, not in a very large sheath	COLUBRIDÆ.
Ventral shields at least nearly as broad as the body; large poison-fangs in a very large sheath below the eye	VIPERIDÆ.

Family TYPHLOPIDÆ.

A single genus.

1. TYPHLOPS.

Schneid. Hist. Amph. ii. p. 339; Bouleng. Cat. Sn. i. p. 7.

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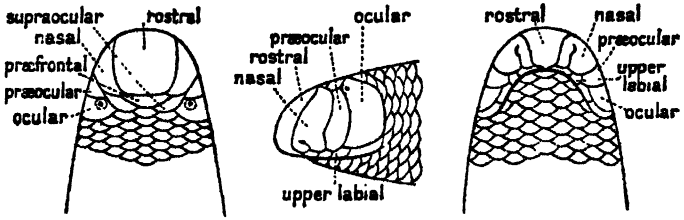
* Published by permission of the Trustees of the British Museum.

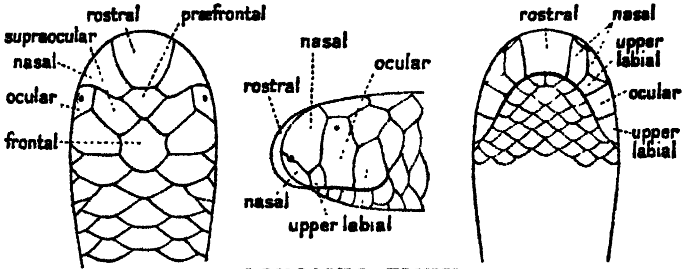
† 1. "A List of the Snakes of the Belgian and Portuguese Congo, Northern Rhodesia, and Angola," P. Z. S. 1915, p. 193. 2. "A List of the Snakes of Madagascar, Comoro, Mascarenes, and Seychelles," t. c. p. 369.

Text-figure 1.

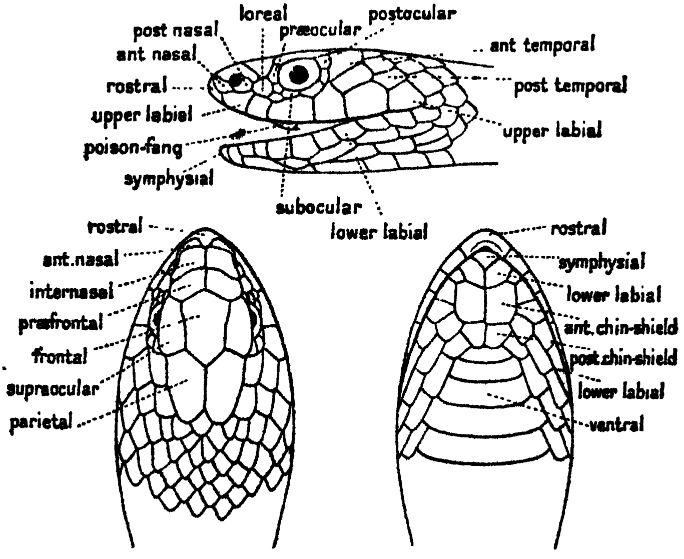
(From P. Z. S. 1915, p. 194.)



TYPHLOPS PUNCTATUS.



GLAUCONIA EMINI.

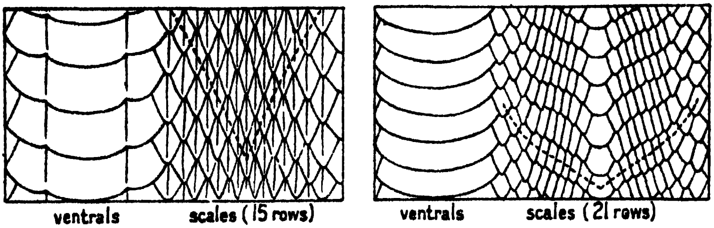


CAUSUS RHOMBEATUS.

J GREEN DEL

Text-figure 2.

(From P. Z. S. 1915, p. 195.)



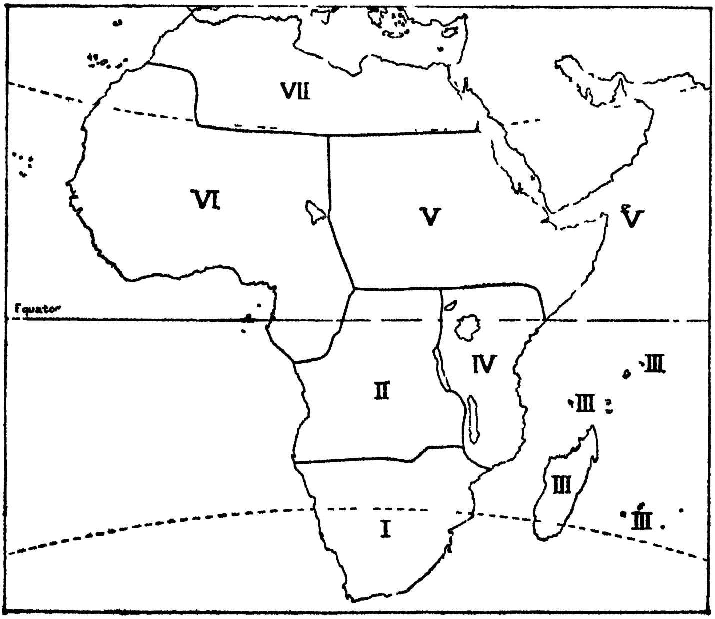
A. B.

Scaling of thickest part of body.

A. *Gastropyxis smaragdina*, with keeled scales and bicarinate ventral shields.
B. *Dipsadomorphus blandingii* with oblique scales and enlarged vertebrals.

The following map (text-fig. 3) shows the boundaries of the divisions adopted in this series of papers. Divisions II and III have been dealt with, the present paper treating of Division IV:

Text-figure 3.



Division of Africa into seven districts.

Synopsis of the Species.

I. No præocular; no subocular; ocular in contact with two upper labials; snout with sharp horizontal edge; eyes hidden; 22 scales round middle of body, the diameter of which is 80 times in total length	*T. gracilis.*
II. A præocular; no subocular; ocular in contact with two or three upper labials.	
A. Nostrils lateral; snout rounded; eyes distinct.	
20 scales round middle of body, the diameter of which is 35 to 50 times in total length	*T. braminus.*
24 scales round middle of body, the diameter of which is 50 to 60 times in total length	*T. platyrhynchus.*
B. Nostrils inferior; snout rounded or with obtusely angular horizontal edge.	
1. Eyes hidden.	
22 or 24 scales round middle of body, the diameter of which is 40 to 50 times in total length	*T. obtusus.*
26 scales round middle of body, the diameter of which is 25 times in total length	*T. tornieri.*
34 scales round middle of body, the diameter of which is 23 times in total length	*T. mandensis.*
2. Eyes distinct.	
a. A small shield separating the præocular from the upper labials; 28 scales round middle of body, the diameter of which is 50 times in total length	*T. gierræ.*
b. Præocular in contact with upper labials.	
Nasal completely divided; 24 scales round middle of body, the diameter of which is 30 times in total length	*T. mossambicus.*
Nasal incompletely divided, the cleft not quite reaching the rostral; 24 scales round middle of body, the diameter of which is 37 or 38 times in total length	*T. tettensis.*
Nasal incompletely divided, the cleft not reaching the rostral; 26 to 30 scales round middle of body, the diameter of which is 24 to 30 times in total length	*T. punctatus.*
C. Nostrils inferior; snout with sharply angular horizontal edge; eyes distinct.	
Lower surface of rostral broader than long; 38 to 44 scales round middle of body, the diameter of which is 25 to 32 times in total length	*T. schlegelii.*
Lower surface of rostral broader than long; 34 to 40 scales round middle of body, the diameter of which is 42 to 46 times in total length	*T. dinga.*
Lower surface of rostral as long as broad; 30 to 38 scales round middle of body, the diameter of which is 25 to 37 times in total length	*T. mucruso.*
III. A præocular; ocular small, separated from the upper labials by a larger subocular; diameter of body 50 to 63 times in total length.	
Snout rounded; eyes hidden; 22 scales round middle of body.	*T. pallidus.*
Snout with sharp horizontal edge; eyes hidden; 18 scales round middle of body	*T. lumbriciformis.*
Snout with sharp horizontal edge; eyes distinct; 24 scales round middle of body	*T. unitæniatus.*

1. TYPHLOPS GRACILIS Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 70.

Urungu, German East Africa.

2. TYPHLOPS BRAMINUS Daud.

Bouleng. Cat. Sn. i. p. 16.

Southern Asia; islands of the Indian Ocean (including Mozambique island); South Africa; Lagos; Mexico.—Distribution probably ascribable to transport by human agency.

3. **Typhlops platyrhynchus** Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 69.

Tanga, German East Africa.

4. **Typhlops obtusus** Peters, Mon. Berl. Ac. 1865, p. 260, pl. —, fig. 2; Bouleng. t. c. p. 38.

Nyassaland.

5. **Typhlops tornieri** Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 69.

Kilimanjaro.

6. **Typhlops mandensis** Stejneg. Proc. U.S. Nat. Mus. xvi. 1894, p. 725; Bouleng. Cat. Sn. iii. p. 587.

Island of Manda, north of Lamu.

7. **Typhlops gierræ** Mocquard, Bull. Mus. Paris, 1897, p. 122.

Tanga, German East Africa.

8. **Typhlops mossambicus.**

Onychocephalus mossambicus Peters, Mon. Berl. Ac. 1854, p. 621.

Typhlops mossambicus Peters, Reise Mossamb. iii. p. 93, pl. xv. fig. 2; Bouleng. Cat. Sn. i. p. 41.

Portuguese East Africa and Zululand.

9. **Typhlops tettensis.**

Onychocephalus tettensis Peters, Mon. Berl. Ac. 1860, p. 80.

Typhlops tettensis Peters, Reise Mossamb. iii. p. 92, pl. xv. fig. 1; Bouleng. Cat. Sn. i. p. 41.

Portuguese East Africa.

10. **Typhlops punctatus** Leach.

Bouleng. Cat. Sn. i. p. 42.

Typhlops bocagii Bethencourt Ferreira, Jorn. Sc. Lisb. (2) vii. 1904, p. 114.

Typhlops adolphi Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 70.

Tropical Africa.

11. **Typhlops schlegelii** Bianconi, Spec. Zool. Mossamb. p. 13, pl. iii. fig. 2; Bouleng. Cat. Sn. i. p. 44.

East and Central Africa to Portuguese East Africa and Southern Rhodesia.

12. **Typhlops dinga.**

Onychocephalus dinga Peters, Mon. Berl. Ac. 1854, p. 620.

Typhlops dinga Peters, Reise Mossamb. iii. p. 98, pl. xiv. fig. 1 & pl. xiv. A, fig. 3; Bouleng. Cat. Sn. i. p. 45.

Portuguese East Africa.

13. TYPHLOPS MUCRUSO.

Onychocephalus mucruso Peters, Mon. Berl. Ac. 1854, p. 621.

Typhlops mucruso Peters, Reise Mossamb. iii. p. 95, pl. xiii. fig. 3; Bouleng. Cat. Sn. i. p. 46.

Typhlops humbo Bocage, Jorn. Sc. Lisb. xi. 1886, p. 171; Bouleng. l. c.

Typhlops hottentotus Bocage, op. cit. (2) iii. 1893, p. 117.

Typhlops latirostris Steinf. Mitth. Zool. Mus. Berl. v. 1910, p. 70.

Tropical Africa south of the Equator.

14. TYPHLOPS PALLIDUS.

Letheobia pallida Cope, Proc. Ac. Philad. 1868, p. 322.

Typhlops pallidus Bouleng. Cat. Sn. i. p. 54.

Zanzibar and Pemba Id.

15. TYPHLOPS LUMBRICIFORMIS.

Onychocephalus (*Letheobia*) *lumbriciformis* Peters, Mon. Berl. Ac. 1874, p. 377.

Typhlops lumbriciformis Bouleng. Cat. Sn. i. p. 54.

Typhlops kleebergi Werner, Zool. Anz. xxvii. 1904, p. 664.

East and Central Africa.

16. TYPHLOPS UNITÆNIATUS Peters, Mon. Berl. Ac. 1878, p. 205, pl. ii. fig. 5; Bouleng. Cat. Sn. i. p. 55, and Ann. Mus. Genova (3) v. 1892, p. 331 (var. *alternatus*).

Somaliland and British East Africa.

Family GLAUCONIIDÆ.

A single genus.

1. GLAUCONIA.

Gray, Cat. Liz. p. 139; Bouleng. Cat. Sn. i. p. 59.

Synopsis of the Species.

I. Ocular bordering the mouth; tail at least three times as long as broad.
  A. Rostral more than half width of head, extending backwards beyond level of eyes.
Diameter of body 50 to 65 times in total length . . . *G. distanti.*
Diameter of body 80 to 87 times in total length . . . *G. merkeri.*
  B. Rostral one third to one half width of head, not extending backwards beyond level of eyes.
    1. Rostral not in contact with supraocular.
Diameter of body 50 to 55 times in total length . . . *G. emini.*
Diameter of body 80 times in total length . . . *G. boulengeri.*
Diameter of body 70 times in total length . . . *G. longicauda.*
    2. Rostral in contact with supraocular; diameter of body 47 to 60 times in total length . . . *G. conjuncta.*
II. Ocular not bordering the mouth; tail hardly twice as long as broad; diameter of body 40 times in total length . . . *G. braueri.*

1. **GLAUCONIA DISTANTI** Bouleng. in Distant, Natur. Transvaal, p. 175, fig., and Cat. Sn. i. p. 62.
Nyassaland, S. Rhodesia, Transvaal.

2. **GLAUCONIA MERKERI** Werner, Jahresh. Ver. Nat. Wurttemb. lxv. 1909, p. 61.
Moschi, German E. Africa.

3. **GLAUCONIA EMINI** Bouleng. Ann. & Mag. N. H. (6) vi. 1890, p. 91, and Cat. Sn. i. p. 64, pl. iii. fig. 8.
East and Central Africa.

4. **GLAUCONIA BOULENGERI** Boettg. in Voeltzkow, Reise Ostafr. iii. p. 354.
Witu, German E. Africa.

5. **GLAUCONIA LONGICAUDA.**

Stenostoma longicauda Peters, Mon. Berl. Ac. 1854, p. 621, and Reise Mossamb. iii. p. 102, pl. xv. fig. 5.
Glauconia longicauda Bouleng. Cat. Sn. i. p. 66.
Portuguese E. Africa and N. Rhodesia.

6. **GLAUCONIA CONJUNCTA.**

Stenostoma conjunctum Jan, Arch. Zool. Anat. Phys. i. 1861, p. 189, and Icon. Gen. l. 2, pls. v. & vi. fig. 9.
Glauconia conjuncta Bouleng. t. c. p. 67.
South and East Africa.

7. **GLAUCONIA BRAUERI** Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 70.
Bagamoyo, German E. Africa.

Family BOIDÆ.

Two genera :—

Upper surface of head with shields, rostral and anterior upper labials deeply pitted, subcaudals in two rows . . . . *Python.*
Upper surface of head with small scales, tail very short, subcaudal single . . . . *Eryx.*

1. PYTHON.

Daud. Hist. Rept. v. p. 266 ; Bouleng. Cat. Sn. i. p. 85.

1. **PYTHON SEBÆ.**

Coluber sebæ Gmel. S. N. i. p. 1118.
Python sebæ Bouleng. t. c. p. 86.
Tropical and South Africa.

2. ERYX.

Daud. Hist. Rept. vii. p. 251; Bouleng Cat. Sn. i. p. 122.

1. ERYX THEBAICUS Reuss, Mus. Senckenb. i. 1834, p. 134; Bouleng. t. c. p. 125.

Upper Egypt to German East Africa.

Family COLUBRIDÆ.

Three parallel series:—

No poison-fangs; all the teeth solid ..... A. Aglypha.
Poison-fangs behind ..... B. Opisthoglypha.
Poison-fangs in front ..... C. Proteroglypha.

A. Aglypha.

I. Loreal present (occasionally absent in *Homalosoma*, recognisable by the combination of a single nasal shield, paired subcaudals, and a low number of ventral shields, 113-144).

A. Snout without angular horizontal edge; internasal and præfrontal paired.

1. Scales in 19 rows or more, not oblique; body not remarkably slender.

a. Pupil round.

α. A single anterior temporal.

Scales in 19 rows; anal divided ..... *Tropidonotus*.
Scales in 19-25 rows; anal entire; a deep groove on side of head, above upper labials ..... *Glypholycus*.

β. Two or three superposed anterior temporals.

Scales keeled, in 23 rows; a deep pit between nasal and præocular ..... *Bothrophthalmus*.
Scales smooth or very obtusely keeled, in 25 to 31 rows ..... *Pseudaspis*.
Scales smooth, in 21 rows ..... *Coronella*.

b. Pupil vertically elliptic; scales smooth, in 23 to 33 rows ..... *Boodon*.

2. Scales in 13 to 17 rows, or, if in 19, extremely narrow and oblique.

a. Pupil vertically elliptic; snout much flattened; scales in 15 or 17 rows.

Scales smooth ..... *Lycophidium*.
Scales keeled, vertebrals bicarinate ..... *Simocephalus*.

b. Pupil round; body usually very slender (tree-snakes).

α. Scales in 13 or 15 rows, smooth.

Subcaudals not keeled ..... *Chlorophis*.
Subcaudals keeled and with a notch corresponding to the keel, same as on the ventrals ..... *Philothamnus*.

β. Scales in 15 rows, keeled.

Subcaudals keeled and notched ..... *Gastropyxis*.
Subcaudals not keeled; two superposed anterior temporals ..... *Hapsidophrys*.

γ. Scales in 17 or 19 rows, very narrow, keeled; eye very large.

Lateral scales shorter than dorsals ..... *Thrasops*.
Lateral scales as long as dorsals ..... *Rhamnophis*.

c. Pupil round; nostril in a single or semidivided nasal; scales not oblique, short and smooth, in 15 or 17 rows.

Nostril directed upwards, nasal divided or semidivided; two superposed anterior temporals; ventrals 145 or more ..... *Grayia*.
Nostril lateral, nasal entire; a single anterior temporal; ventrals less than 145 ..... *Homalosoma*.

B. Snout with angular horizontal edge, or internasal and præfrontal single.
Eye in contact with labials; internasal and præfrontal single; scales in 15 or 17 rows; ventrals less than 170 *Prosymna.*
Suboculars separate the eye from the labials; scales in 19 to 25 rows; ventrals more than 170 .. *Scaphiophis.*
II. No loreal, nasal in contact with præocular; pupil vertically elliptic; scales strongly keeled, some of the laterals very oblique *Dasypeltis.*

1. Tropidonotus.

Kuhl, Bull. Sc. Nat. ii. 1824. p. 81; Bouleng. Cat. Sn. i. p. 192.

1. **Tropidonotus olivaceus.**

Coronella olivacea Peters, Mon. Berl. Ac. 1854, p. 622.
Tropidonotus olivaceus Bouleng. t. c. p. 227.
Grayia guardi Dollo, Bull. Mus. Belg. iv. 1886, p. 158, fig.; Bouleng. op. cit. ii. p. 288.

Tropical Africa, from the Soudan to Angola, and Southern Rhodesia.

2. Glypholycus.

Günth. P. Z. S. 1893, p. 629: Bouleng. Cat. Sn. iii. p. 615.

Two species:

Scales in 23 or 25 rows, nasal semidivided *G. bicolor.*
Scales in 19 rows, nasal divided *G. whytii.*

1. **Glypholycus bicolor** Günth. l. c., fig.; Bouleng. l. c.

Lake Tanganyika.

2. **Glypholycus whytii** Bouleng. P. Z. S. 1897, p. 802, pl. xlvi. fig. 2.

Nyassaland.

3. Bothrophthalmus.

Peters, Mon. Berl. Ac. 1863, p. 287; Bouleng. Cat. Sn. i. p. 324.

1. **Bothrophthalmus lineatus.**

Elaphis (*Bothrophthalmus*) *lineatus* Peters, l. c.
Bothrophthalmus lineatus Bouleng. l. c.

From the Gold Coast and Uganda to the Congo.

4. Boodon.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 460; Bouleng. Cat. Sn. i. p. 327.

Synopsis of the Species.

I. Subcaudals in two rows.
Præocular not extending to upper surface of head; scales in 23 or 25 rows; ventrals 175-195; no light lines on side of head *B. infernalis.*

Præocular extending to upper surface of head; scales in 23 (rarely 25) rows; ventrals 186–220; belly blackish brown with the middle line yellowish .... *B. virgatus.*

Præocular extending to upper surface of head; scales in 25 to 33 rows; ventrals 188–240 .... *B. lineatus.*

II. Subcaudals single; scales in 25 to 29 rows: ventrals 183–221... *B. olivaceus.*

1. **BOODON INFERNALIS** Günth. Cat. Col. Sn. p. 199; Bouleng. Cat. Sn. i. p. 330, pl. xxi. fig. 1.

German East Africa and South Africa.

2. **BOODON VIRGATUS.**

Cœlopeltis virgata Hallow. Proc. Ac. Philad. 1854, p. 98.
Boodon virgatus Bouleng. t. c. p. 331.

German East Africa (*fide* Sternfeld); West Africa, from the Gold Coast to Calabar.

3. **BOODON LINEATUS** Dum. & Bibr. Erp. Gén. vii. p. 363; Bouleng. t. c. p. 332.

Tropical and South Africa and South Arabia.

4. **BOODON OLIVACEUS.**

Holuropholis olivaceus A. Dum. Rev. et Mag. Zool. 1856, p. 466.
Boodon olivaceus Bouleng. t. c. p. 335.

West and Central Africa, from Nigeria and Uganda to the Congo.

5. LYCOPHIDIUM.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 462; Bouleng. Cat. Sn. i. p. 336.

Synopsis of the Species.

I. Scales in 15 rows; ventrals 153–165; subcaudals 23–32 ... *L. meleagris.*

II. Scales in 17 rows.

A. Parietal shields longer than the distance between frontal and end of snout.

Diameter of eye hardly equal to its distance from mouth; ventrals 140–150; subcaudals 18–28 .... *L. acutirostre.*

Diameter of eye considerably greater than its distance from mouth; ventrals 146–156; subcaudals 20–30 .... *L. semiannulis.*

Diameter of eye considerably greater than its distance from mouth; ventrals 163–208; subcaudals 24–47 .... *L. capense.*

Diameter of eye not greater than its distance from mouth; ventrals 164–189; subcaudals 29–33 .... *L. jacksonii.*

B. Parietal shields not longer than distance between frontal and end of snout; ventrals 188–219; subcaudals 34–55 .... *L. semicinctum.*

1. **LYCOPHIDIUM MELEAGRIS** Bouleng. Cat. Sn. i. p. 337, pl. xxi. fig. 2.

German East Africa (*fide* Sternfeld); Angola.

2. **LYCOPHIDIUM ACUTIROSTRE** Günth. Ann. & Mag. N. H. (4) i. 1868, p. 427, pl. xix. fig. D; Bouleng. t. c. p. 338.

Zanzibar.

3. **LYCOPHIDIUM SEMIANNULIS** Peters, Mon. Berl. Ac. 1854, p. 622, and Reise Mossamb. iii. p. 135, pl. xvi. fig. 2; Bouleng. t. c. p. 339.

Portuguese East Africa.

4. **LYCOPHIDIUM CAPENSE.**

Lycodon capensis A. Smith, S. Afr. Quart. Journ. (1) no. 5. 1831, p. 18.

Lycophidium capense Bouleng. t. c. p. 339.

Tropical and South Africa.

5. **LYCOPHIDIUM JACKSONII** Bouleng. Cat. Sn. i. p. 340, pl. xxi. fig. 3.

East Africa (Kilimanjaro, Lamu).

6. **LYCOPHIDIUM SEMICINCTUM** Dum. & Bibr. Erp. Gén. vii. p. 414; Bouleng. t. c. p. 341.

German East Africa (*fide* Sternfeld); Senegambia, French Guinea, Northern Nigeria.

6. SIMOCEPHALUS.

Günth. Cat. Col. Sn. p. 194: Bouleng. Cat. Sn. i. p. 341.

Synopsis of the Species.

I. Ventrals 203-255; subcaudals 45-70.	
Two postoculars; a yellow vertebral line .	*S. capensis.*
Three postoculars; a single loreal . .	*S. chanleri*
Three postoculars; two superposed loreals .	*S. unicolor.*
II. Ventrals 239-262; subcaudals 75-124	*S. poensis.*
III. Ventrals 171-178; subcaudals 62-63	*S. nyassæ.*

1. **SIMOCEPHALUS CAPENSIS.**

Heterolepis capensis A. Smith, Ill. Zool. S. Afr., Rept. pl. lv.

Simocephalus capensis Bouleng. t. c. p. 345.

German and Portuguese East Africa, Nyassaland, Gaboon, Natal.

2. **SIMOCEPHALUS CHANLERI** Stejneg. Proc. U.S. Nat. Mus. xvi. 1894, p. 726; Bouleng. op. cit. iii. p. 617.

Island of Manda, N. of Lamu.

3. **SIMOCEPHALUS UNICOLOR** Bouleng. Ann. & Mag. N. H. (8) v. 1910, p. 512.

Kenya District, Brit. E. Africa.

4. **SIMOCEPHALUS POENSIS.**

Heterolepis poensis A. Smith, Ill. Zool. S. Afr., Rept.

Simocephalus poensis Bouleng. op. cit. i. p. 346.

Uganda; Sierra Leone to Congo.

5. SIMOCEPHALUS NYASSÆ Günth. Ann. & Mag. N. H. (6) i. 1888, p. 328; Bouleng. t. c. p. 347, pl. xxiii. fig. 2.

Gonionotophis degrijsii Werner, Zool. Anz. xxx. 1906, p. 53.

East Africa, Nyassaland, Natal.

7. PSEUDASPIS.

Cope, Proc. Ac. Philad. 1864, p. 168; Bouleng. Cat. Sn. i. p. 373.

1. PSEUDASPIS CANA.

Coluber canus Linn. Mus. Ad. Frid. i. p. 31, pl. xi. fig. 1.

Pseudaspis cana Bouleng. l. c.

East and South Africa, Nyassaland, Angola.

8. CHLOROPHIS.

Hallow. Proc. Ac. Philad. 1857, p. 52; Bouleng. Cat. Sn. ii. p. 91.

Synopsis of the Species.

I. No trace of ventral keels; ventrals 147–190.

A. Scales in 15 rows.

9 upper labials, 4th, 5th, and 6th entering the eye; subcaudals 103–123 .... *C. emini.*

7 upper labials, 3rd, 4th, and 5th entering the eye; subcaudals 114 .... *C. schubotzi.*

8 upper labials, 4th and 5th entering the eye; subcaudals 82–105 .... *C. hoplogaster.*

B. Scales in 13 rows; 9 upper labials, 5th and 6th entering the eye; subcaudals 75 .... *C. macrops.*

II. Ventrals with a more or less distinct lateral keel.

7 or 8 upper labials, 4th and 5th (rarely 3rd and 4th) entering the eye; ventrals 148–169; subcaudals 71–114 .... *C. neglectus.*

8 or 9 upper labials, 4th, 5th, and 6th (rarely 3rd, 4th, and 5th) entering the eye; ventrals 175–190; subcaudals 115–135; body very slender anteriorly .... *C. heterolepidotus.*

9 upper labials, 4th, 5th, and 6th entering the eye; præocular in contact with or narrowly separated from the frontal; ventrals 150–182; subcaudals 90–133 .... *C. irregularis.*

1. CHLOROPHIS EMINI.

Ahætulla emini Günth. Ann. & Mag. N. H. (6) i. 1888, p. 325.

Chlorophis emini Bouleng. t. c. p. 92, pl. v. fig. 1.

Egyptian Soudan to Uganda and Ruwenzori.

2. CHLOROPHIS SCHUBOTZI Sternf. in Schubotz, Wiss. Ergebn. Deutsch. Z.-Afr. Exped. iv. Zool. ii. p. 269, fig. (1912).

Near Bukoba, German E. Africa.

3. CHLOROPHIS HOPLOGASTER.

Ahætulla hoplogaster Günth. Ann. & Mag. N. H. (3) xi. 1863, p. 284.

Chlorophis hoplogaster Bouleng. t. c. p. 93.

Central, East, and South Africa.

4. CHLOROPHIS MACROPS.

Oligolepis macrops Bouleng. op. cit. iii. p. 644.
Chlorophis macrops Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 95.

German East Africa.

5. CHLOROPHIS NEGLECTUS.

Philothamnus neglectus Peters, Mon. Berl. Ac. 1866, p. 890, and Reise Mossamb. iii. p. 130, pl. xix. A, fig. 2.
Chlorophis neglectus Bouleng. op. cit. ii. p. 94.

East and Central Africa, S. Rhodesia.

6. CHLOROPHIS HETEROLEPIDOTUS.

Ahætulla heterolepidota Günth. Ann. & Mag. N. H. (3) xi. 1863, p. 286.
Chlorophis heterolepidotus Bouleng. t. c. p. 95.
Chlorophis gracilis Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 64.

Tropical Africa.

7. CHLOROPHIS IRREGULARIS.

Coluber irregularis Leach, in Bowdich, Miss. Ashantee, p. 494.
Chlorophis irregularis Bouleng. t. c. p. 96.

Senegambia and Uganda to Damaraland and S. Rhodesia.

9. PHILOTHAMNUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. ii. p. 98.

1. PHILOTHAMNUS SEMIVARIEGATUS A. Smith, t. c. pls. lix., lx., & lxiv. fig. 1; Bouleng. t. c. p. 99.

Tropical and South Africa.

10. GASTROPYXIS.

Cope, Proc. Ac. Philad. 1860, p. 556; Bouleng. Cat. Sn. ii. p. 102.

Two species:—

Temporals 1+2; scales strongly keeled ... . *G. smaragdina.*
Temporals 2+2; scales feebly keeled . . .. *G. orientalis.*

1. GASTROPYXIS SMARAGDINA.

Dendrophis smaragdina Schleg. Phys. Serp. ii. p. 237.
Gastropyxis smaragdina Bouleng. t. c. p. 103.

Tropical Africa, from Sierra Leone and Uganda to the Congo and Northern Angola.

2. GASTROPYXIS ORIENTALIS Werner, Jahresh. Ver. Nat. Württemb. lxv. 1909, p. 55.

German East Africa.

11. HAPSIDOPHRYS.

Fischer, Abh. Nat. Ver. Hamb. iii. 1856, p. 110; Bouleng. Cat. Sn. ii. p. 103.

1. HAPSIDOPHRYS LINEATA Fischer, t. c. p. 111, pl. ii. fig. 5; Bouleng. t. c. p. 104.

From the Gold Coast to the Congo, eastwards to Uganda.

12. THRASOPS.

Hallow. Proc. Ac. Philad. 1857, p. 67; Bouleng. Cat. Sn. ii. p. 104.

1. THRASOPS ROTHSCHILDII Mocquard, Bull. Mus. Paris, 1905, p. 286.

British East Africa.

13. RHAMNOPHIS.

Günth. Ann. & Mag. N. H. (3) ix. 1862, p. 129; Bouleng. Cat. Sn. iii. p. 632.

1. RHAMNOPHIS JACKSONII.

Thrasops jacksonii Günth. Ann. & Mag. N. H. (6) xv. 1895, p. 528; Bouleng. l. c.

Uganda, French Guinea, Gold Coast, Kasai.

14. CORONELLA.

Laur. Syn. Rept. p. 84; Bouleng. Cat. Sn. ii. p. 188.

Two species:—

Rostral much broader than deep	*C. semiornata.*
Rostral scarcely broader than deep	*C. scheffleri.*

1. CORONELLA SEMIORNATA Peters, Mon. Berl. Ac. 1854, p. 622, and Reise Mossamb. iii. p. 116, pl. xvii. fig. 2; Bouleng. t. c. p. 195.

East Africa, N. Rhodesia.

2. CORONELLA SCHEFFLERI Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 93.

British East Africa.

15. GRAYIA.

Günth. Cat. Col. Sn. p. 50; Bouleng. Cat. Sn. ii. p. 286.

Two species:

Scales in 17 rows; ventrals 145-168, subcaudals 89-102	*G. smythii.*
Scales in 15 rows; ventrals 130-143; subcaudals 100-128	*G. tholloni.*

1. **GRAYIA SMYTHII.**

Coluber smythii Leach, in Tuckey's Explor. R. Zaire, App. p. 309.

Grayia smythii Bouleng. t. c. (part.), and P. Z. S. 1899, p. 948, figs.

West and Central Africa and Uganda.

2. **GRAYIA THOLLONI** Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 11; Bouleng. P. Z. S. 1899, p. 951, fig.

Egyptian Soudan, Uganda, French Congo, Katanga.

16. HOMALOSOMA.

Wagl. Syst. Amph. p. 190; Bouleng. Cat. Sn. ii. p. 273.

1. **HOMALOSOMA LUTRIX.**

Coluber lutrix Linn. S. N. i. p. 375.

Homalosoma lutrix Bouleng. t. c. p. 274.

Homalosoma shiranum Bouleng. t. c. p. 276.

Homalosoma abyssinicum Bouleng. l. c.

East Africa, Nyassaland, South Africa.

17. PROSYMNA.

Gray, Cat. Sn. p. 80; Bouleng. Cat. Sn. ii. p. 246.

Synopsis of the Species.

Snout with angular horizontal edge; two postoculars; ventrals 131-153	*P. ambigua*
Snout with angular horizontal edge, a single postocular; præfrontal entering the eye; ventrals 151-167 . .	*P. bocagii.*
Snout rounded; two postoculars; ventrals 140-143	*P. variabilis.*

1. **PROSYMNA AMBIGUA** Bocage, Jorn. Sc. Lisb. iv. 1873, p. 218; Bouleng. t. c. p. 248.

Zanzibar Coast to Zululand, N. Rhodesia, Angola.

2. **PROSYMNA BOCAGII** Bouleng. Ann. & Mag. N. H. (6) xix. 1897, p. 278, fig., and Ann. Mus. Congo, Zool. ii. 1901, p. 9, pl. iii. fig. 4.

Prosymna cassei Mocquard, Bull. Mus. Paris, 1906, p. 250.

Ubanghi and Mozambique.

3. Prosymna variabilis Werner, Jahresh. Nat. Ver. Württemb. lxv. 1909, p. 57.

Moschi, German E. Africa.

18. Scaphiophis.

Peters, Mon. Berl. Ac. 1870, p. 644; Bouleng. Cat. Sn. ii. p. 254.

1. Scaphiophis albopunctatus Peters, t. c. p. 645, pl. i. fig. 4; Bouleng. l. c.

Tropical Africa, from the Soudan to the Congo.

19. Dasypeltis.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. ii. p. 353.

1. Dasypeltis scabra.

Coluber scaber Linn. Mus. Ad. Frid. p. 36, pl. x. fig. 1.
Dasypeltis scabra Bouleng. t. c. p. 254.
Tropical and South Africa, Egypt, S. Arabia.

B. Opisthoglypha.

I. Eye moderate or large, with vertically elliptic pupil; head distinct from neck; nostril between two shields; loreal present (sometimes entering the eye).
  A. Nostril directed upwards, between the nasal and the internasal; parietals broken up into small shields; scales smooth or obtusely keeled, in 21 rows .... *Pythonodipsas.*
  B. Nostril between two nasals; scales smooth or faintly keeled.
    1. Two superposed anterior temporals; scales oblique.
Scales in 19 or 21 rows, vertebrals not enlarged . . . . . . *Tarbophis.*
Scales in 21 to 25 rows, vertebrals enlarged . . . . *Dipsadomorphus.*
    2. A single anterior temporal.
Scales in 19 rows (rarely 17); loreal not entering eye . *Leptodira.*
Scales in 17 rows; loreal entering eye .... *Chamætortus.*
II. Eye small, with vertically subelliptic pupil; head distinct from neck; nasal semidivided, with horizontal cleft; scales in 17 or 19 rows .... *Hemirhagerrhis.*
III. Eye moderate or large, with round or horizontal pupil; head distinct from neck; loreal present.
  A. Pupil round.
    1. Loreal not more than once and a half as long as deep; scales in 17 or 19 rows, not oblique.
Nostril between two nasals; ventrals 128–139; subcaudals 34–44 .... *Geodipsas.*
Nostril in a semidivided nasal; internasals shorter than præfrontals; ventrals 147–187; subcaudals 59–98 ... . *Amplorhinus.*
Nostril between two nasals and the internasal; subcaudals less than 70 .... *Trimerorhinus.*
Nostril between two nasals; rostral very large; subcaudals 90 or more .... *Rhamphiophis.*
    2. Loreal at least once and a half as long as deep; scales more or less oblique.
Scales in 17 rows; a single anterior temporal. .... *Dromophis.*
Scales in 11 to 17 rows; one or two middle maxillary teeth much enlarged, fang-like .... *Psammophis.*

3. Loreal not more than once and a half as long as deep; nostril in an undivided nasal; scales very narrow, oblique, keeled, in 19 or 21 rows .. . . *Dispholidus.*

B. Pupil horizontal; nostril in an undivided nasal; scales narrow, oblique, feebly keeled, in 19 rows . . . . *Thelotornis.*

IV. Eye small or very small; head not at all distinct from neck; no loreal.

A. Subcaudals in two rows.

1. One or two upper labials in contact with the parietal; nasal in contact with the rostral.

Scales in 19 or 21 rows; no præocular . . . *Calamelaps.*

Scales in 15 or 17 rows; no præocular; rostral very large, concave below; a pair of internasals and a pair of præfrontals. *Rhinocalamus.*

Scales in 17 rows; a large, elongate præocular; rostral very large, flat below; præfrontals absent .. .. *Xenocalamus.*

2. Temporals separate the upper labials from the parietals; scales in 15 rows.

Nasal in contact with the rostral; no præocular ... . *Micrelaps.*

First upper labial in contact with the internasal; a præocular . *Miodon.*

B. Subcaudals single; a præocular; scales in 15 rows ... . *Aparallactus.*

1. GEODIPSAS.

Bouleng. Cat. Sn. iii. p. 32.

1. GEODIPSAS VAUEROCEGÆ Tornier, Zool. Anz. xxv. 1902, p. 703.

Usambara, German E. Africa.

2. PYTHONODIPSAS.

Günth. Ann. & Mag. N. H. (4) i. 1868, p. 425; Bouleng. Cat. Sn. iii. p. 45.

1. PYTHONODIPSAS CARINATA Günth. t. c. p. 426, pl. xix. fig. K; Bouleng. l. c.

Zambesi, Damaraland.

3. TARBOPHIS.

Fleischm. Dalm. nov. Serp. Gen. p. 17; Bouleng. Cat. Sn. iii. p. 47.

Two species:—

Scales in 19 rows; anal divided . . *T. semiannulatus.*

Scales in 21 rows (rarely 19); anal entire . .. .. *T. guentheri.*

1. TARBOPHIS SEMIANNULATUS.

Telescopus semiannulatus A. Smith, Ill. Zool. S. Afr., Rept. pl. lxxii.

Tarbophis semiannulatus Bouleng. t. c. p. 51.

Central and East Africa, Angola, S. Africa.

2. TARBOPHIS GUENTHERI Anders. Proc. Zool. Soc. 1895, pl. xxxvi. fig. 3; Bouleng. t. c. p. 52.

East Africa, Arabia, Syria.

4. DIPSADOMORPHUS.

Fitzing. in Tschudi, Faun. Per., Herp. p. 55; Bouleng. Cat. Sn. iii. p. 59.

1. DIPSADOMORPHUS BLANDINGII.

Dipsas blandingii Hallow. Proc. Ac. Philad. 1844, p. 170.
Dipsadomorphus blandingii Bouleng. t. c. p. 77.

British East Africa; West Africa, from Senegambia to Congo.

5. LEPTODIRA.

Günth. Cat. Col. Sn. p. 165; Bouleng. Cat. Sn. iii. p. 88.

Synopsis of the Species.

I. Ventrals less than 200; subcaudals less than 60; 3 to 5 pairs of chin-shields.	
One præocular (rarely divided), separated from the frontal; frontal considerably broader than deep; loreal not or but little longer than deep	*L. hotambœia.*
One præocular, separated from the frontal; rostral little broader than deep; loreal longer than deep	*L. degeni.*
Two præoculars, upper in contact with the frontal	*L. tornieri.*
II. Ventrals more than 200; subcaudals 100 or more; two pairs of chin-shields	*L. werneri.*

1. LEPTODIRA HOTAMBŒIA.

Coronella hotambœia Laur. Syn. Rept. p. 85.
Leptodira hotambœia Bouleng. t. c. p. 89.

Tropical and South Africa.

2. LEPTODIRA DEGENI Bouleng. Proc. Zool. Soc. 1906, ii. p. 572, fig.

Leptodira attarensis Werner, Sitzb. Ak. Wien, cxvi. 1907, p. 1875.

Uganda.

3. LEPTODIRA TORNIERI Werner, t. c. p. 1876.

Usambara, German East Africa.

4. LEPTODIRA WERNERI Bouleng. Ann. & Mag. N. H. (6) xix. 1897, p. 281.

Dipsadomorphus reticulatus Werner, Jahresh. Nat. Ver. Württemb. lxv. 1909, p. 55.

Usambara, German East Africa.

6. CHAMÆTORTUS.

Günth. Proc. Zool. Soc. 1864, p. 310; Bouleng. Cat. Sn. iii. p. 98.

1. CHAMÆTORTUS AULICUS Günth. l. c. pl. xxvi. fig. 2; Bouleng. l. c.

German and Portuguese East Africa, Transvaal.

7. HEMIRHAGERRHIS.

Boettg. Zool. Anz. 1893, p. 119; Bouleng. Cat. Sn. iii. p. 119.

1. **HEMIRHAGERRHIS KELLERI** Boettg. l. c.; Bouleng. l. c.
Somaliland and British East Africa.

8. AMPLORHINUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 124.

Two species:—

Temporals 1+2 or 2+2; ventrals 154-187	*A. nototænia.*
Temporals 3+4; ventrals 117	*A. tæniatus.*

1. **AMPLORHINUS NOTOTÆNIA.**

Coronella nototænia Günth. P. Z. S. 1864, p. 309, pl. xxvi. fig. 1.
Amplorhinus nototænia Bouleng. t. c. p. 125.
Amplorhinus güntheri Mocquard. Bull. Mus. Paris, 1896, p. 251.

Egyptian Soudan to Nyassaland; Angola.

2. **AMPLORHINUS TÆNIATUS** Sternf. Mitth. Zool. Mus. Berl. iv. 1908, p. 241.

Lamu Id., British East Africa.

9. TRIMERORHINUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 138.

Two species:—

Rostral as deep as broad, its upper portion at least half as long as its distance from the frontal	*T. tritæniatus.*
Rostral slightly broader than deep, its upper portion about one third its distance from the frontal	*T. variabilis.*

1. **TRIMERORHINUS TRITÆNIATUS.**

Rhagerrhis tritæniata Günth. Ann. & Mag. N. H. (4) i. 1868, p. 423, pl. xix. fig. H.
Trimerorhinus tritæniatus Bouleng. t. c. p. 139.

East, Central, and South Africa.

Probably only a variety of the S. African *T. rhombeatus.*

2. **TRIMERORHINUS VARIABILIS.**

Psammophylax variabilis Günth. P. Z. S. 1892, p. 557, pl. xxxv.
Trimerorhinus variabilis Bouleng. t. c. p. 140.

Nyassaland.

10. RHAMPHIOPHIS.

Peters, Mon. Berl. Ac. 1854, p. 624; Bouleng. Cat. Sn. iii. p. 144.

Two species:—

Snout rounded; scales in 19 rows; ventrals 230–241; subcaudals 154–160	*R. rubropunctatus.*
Snout somewhat hooked in profile; scales in 17 rows; ventrals 148–192; subcaudals 90–110	*R. oxyrhynchus.*

1. **RHAMPHIOPHIS RUBROPUNCTATUS.**

Dipsina rubropunctata Fischer, Jahrb. Hamb. Wiss. Anst. i. 1884, p. 7, pl. i. fig. 3.

Rhamphiophis rubropunctatus Bouleng. t. c. p. 146.

Egyptian Soudan and East Africa.

2. **RHAMPHIOPHIS OXYRHYNCHUS.**

Psammophis oxyrhynchus Reinh. Vid. Selsk. Skrift. x. 1843, p. 244.

Rhamphiophis oxyrhynchus Bouleng. l. c.

Tropical Africa.

11. DROMOPHIS.

Peters, Mon. Berl. Ac. 1869, p. 447; Bouleng. Cat. Sn. iii. p. 149.

1. **DROMOPHIS LINEATUS.**

Dryophylax lineatus Dum. & Bibr. Erp. Gén. vii. p. 1124.

Dromophis lineatus Bouleng. l. c.

Coast of Guinea to Egyptian Soudan and Zanzibar Coast; Nyassaland.

12. PSAMMOPHIS.

Boie, Isis, 1827, p. 521; Bouleng. Cat. Sn. iii. p. 152.

Synopsis of the Species.

I. Scales in 17 rows; 2 or 3 superposed anterior temporals.	
Rostral broader than deep; ventrals 177–192; subcaudals 130–178	*P. punctulatus.*
Rostral broader than deep; ventrals 151–180; subcaudals 100–119	*P. subtæniatus.*
Rostral as deep as broad	*P. sibilans.*
II. Scales in 15 rows; 2 superposed anterior temporals	*P. biseriatus.*
III. Scales in 11 rows; a single anterior temporal	*P. angolensis.*

1. **PSAMMOPHIS PUNCTULATUS** Dum. & Bibr. Erp. Gén. vii. p. 897; Bouleng. t. c. p. 159.

East Africa, from the Blue Nile to Mozambique; Arabia.

2. PSAMMOPHIS SUBTÆNIATUS.

Psammophis sibilans, var. *subtæniata* Peters, Reise Mossamb. iii. p. 121.

Psammophis subtæniatus Bouleng. t. c. p. 160.

East Africa, from Uganda to Mozambique; Nyassaland.

3. PSAMMOPHIS SIBILANS.

Coluber sibilans Linn. S. N. i. p. 383.

Psammophis sibilans Bouleng. t. c. p. 161.

Psammophis trinasalis Werner, Abh. Bayer. Ak. xxii. 1903, p. 381.

Tropical and South Africa; Egypt.

4. PSAMMOPHIS BISERIATUS Peters, Sitzb. Ges. Nat. Fr. Berl. 1881, p. 88; Bouleng. t. c. p. 168.

Somaliland and British East Africa.

5. PSAMMOPHIS ANGOLENSIS.

Amphiophis angolensis Bocage, Jorn. Sc. Lisb. iv. 1872, p. 82.

Psammophis angolensis Bouleng. t. c. p. 170.

East and Central Africa, Angola, Orange River Colony.

13. THELOTORNIS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 184.

1. THELOTORNIS KIRTLANDII.

Leptophis kirtlandii Hallow. Proc. Ac. Philad. 1844, p. 62.

Thelotornis kirtlandii Bouleng. t. c. p. 185.

Tropical and South Africa.

14. DISPHOLIDUS.

Duvernoy, Ann. Sc. Nat. xxvi. 1832, p. 150; Bouleng. Cat. Sn. iii. p. 186.

1. DISPHOLIDUS TYPUS.

Bucephalus typus A. Smith, Zool. Journ. iv. 1829, p. 441.

Dispholidus typus Bouleng. t. c. p. 187.

Tropical and South Africa.

15. CALAMELAPS.

Günth. Ann. & Mag. N. H. (3) xviii. 1866, p. 26; Bouleng. Cat. Sn. iii. p. 245.

Two species:—

Scales in 17 rows .... *C. unicolor.*
Scales in 19 or 21 rows .... *C. polylepis.*

1. **CALAMELAPS UNICOLOR.**

Calamaria unicolor Reinh. Vid. Selsk. Skrift. x. 1843, p. 236, pl. i. figs. 1–3.

Calamelaps unicolor Bouleng. l. c.

Atractaspis hildebrandti Peters, Mon. Berl. Ac. 1877, p. 616; Bouleng. t. c. p. 512.

British East Africa; West Africa.

2. **CALAMELAPS POLYLEPIS** Bocage, Jorn. Sc. Lisb. iv. 1873, p. 216; Bouleng. t. c. p. 246.

Nyassaland, Angola.

16. RHINOCALAMUS.

Günth. Ann. & Mag. N. H. (6) i. 1888, p. 322; Bouleng. Cat. Sn. iii. p. 247.

Two species:—

Scales in 17 rows; 6 upper labials	*R. dimidiatus.*
Scales in 15 rows; 7 upper labials	*R. meleagris.*

1. **RHINOCALAMUS DIMIDIATUS** Günth. l. c. pl. xix. fig. C; Bouleng. l. c.

East Africa.

2. **RHINOCALAMUS MELEAGRIS** Sternf. Mitth. Zool. Mus. Berl. iv. 1908, p. 244.

Lamu Id., British East Africa.

17. XENOCALAMUS.

Günth. Ann. & Mag. N. H. (4) i. 1868, p. 414; Bouleng. Cat. Sn. iii. p. 247.

1. **XENOCALAMUS BICOLOR** Günth. t. c. p. 415, pl. xix. fig. A; Bouleng. t. c. p. 248.

Zambesi.

18. MICRELAPS.

Boettg. Ber. Senck. Ges. 1879–80, p. 136; Bouleng. Cat. Sn. iii. p. 248.

1. **MICRELAPS BICOLORATUS** Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 93.

British East Africa.

19. MIODON.

A. Dum. Arch. Mus. x. 1859, p. 206; Bouleng. Cat. Sn. iii. p. 249.

Synopsis of the Species.

Frontal slightly broader than supraocular, $1\frac{1}{3}$ to $1\frac{1}{2}$ as long as broad	*M. gabonensis.*
Frontal much broader than the supraocular, a little longer than broad; nasal entire	*M. christyi.*
Frontal much broader than the supraocular, as broad as long . ..	*M. graueri.*

1. MIODON GABONENSIS.

Elapomorphus gabonensis A. Dum. Rev. et Mag. Zool. (2) viii. 1856, p. 468.

Miodon gabonensis Bouleng. t. c. p. 252.

Old Calabar to Congo; German East Africa.

2. **MIODON CHRISTYI** Bouleng. Ann. & Mag. N. H. (7) xii. 1903, p. 354.

Uganda.

3. **MIODON GRAUERI** Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 94, and Faun. Deutsch. Kolon. iii. 2, p. 34, fig.

Uganda.

Perhaps not specifically distinct from the preceding.

20. APARALLACTUS.

A. Smith, Ill. Zool. S. Afr., Rept. App. p. 15; Bouleng. Cat. Sn. iii. p. 255.

Synopsis of the Species.

I. Symphysial not in contact with the chin-shields.

A. Two postoculars, in contact with a temporal; nasal entire, in contact with the præocular.

Third and fourth upper labials entering the eye .. *A. jacksonii.*
Second and third upper labials entering the eye *A. werneri.*

B. A single postocular; one upper labial in contact with the parietal.

Nasal entire, not in contact with præocular .. *A. concolor.*
Nasal divided, in contact with præocular: upper part of rostral about one third its distance from frontal *A. lunulatus.*
Nasal divided, in contact with præocular; upper part of rostral two thirds its distance from frontal *A. christyi.*

II. Symphysial in contact with the chin-shields.

A. Third and fourth upper labials entering the eye.

Nasal divided; subcaudals 49–59 . . *A. guentheri.*
Nasal entire; subcaudals 37–53 . .. . *A. capensis.*

B. Second and third upper labials entering the eye.

Ventrals 110–149 . .. . . *A. nigriceps.*
Ventrals 157–162 .. .. *A. punctatolineatus.*

1. APARALLACTUS JACKSONII.

Uriechis jacksonii Günth. Ann. & Mag. N. H. (6) i. 1888, p. 325, pl. xix. fig. E.

Aparallactus jacksonii Bouleng. t. c. p. 256.

East Africa.

2. **APARALLACTUS WERNERI** Bouleng. Ann. & Mag. N. H. (6) xvi. 1895, p. 172, and Cat. Sn. iii. p. 257, pl. xi. fig. 1.

Usambara, German East Africa.

3. APARALLACTUS CONCOLOR.

Uriechis concolor Fischer, Jahrb. Hamb. Wiss. Anst. i. 1884, p. 4, pl. i.

Aparallactus concolor Bouleng. Cat. Sn. iii. p. 257.

Uganda and Somaliland.

4. APARALLACTUS LUNULATUS.

Uriechis lunulatus Peters, Mon. Berl. Ac. 1854, p. 623, and Reise Mossamb. iii. p. 113, pl. xviii. fig. 2.

Aparallactus lunulatus Bouleng. t. c. p. 258.

Lake Tanganyika, Nyassaland, Mozambique.

5. APARALLACTUS CHRISTYI Bouleng. Ann. & Mag. N. H. (8) v. 1910, p. 512.

Uganda.

6. APARALLACTUS GUENTHERI Bouleng. Ann. & Mag. N. H. (6) xvi. 1895, p. 172, and t. c. p. 259.

East and Central Africa, S. Rhodesia, Angola.

7. APARALLACTUS CAPENSIS A. Smith, Ill. Zool. S. Afr., Rept. App. p. 16; Bouleng. Cat. Sn. iii. p. 259.

East and South Africa, Katanga.

8. APARALLACTUS NIGRICEPS.

Uriechis nigriceps Peters, Mon. Berl. Ac. 1854, p. 623, and Reise Mossamb. iii. p. 111, pl. xviii. fig. 1.

Aparallactus nigriceps Bouleng. t. c. p. 260.

Mozambique and Nyassaland.

9. APARALLACTUS PUNCTATOLINEATUS Bouleng. Ann. & Mag. N. H. (6) xvi. 1895, p. 173, and Cat. Sn. iii. p. 261.

Nyassaland, Angola.

C. Proteroglypha.

(Loreal absent in all the genera.)

I. Tail compressed; no distinct ventrals (Marine) .... *Hydrus.*

II. Tail not compressed; ventrals large.

A. Head short; snout broader than long; body cylindrical; subcaudals less than 80.

Scales not at all oblique; ventrals 192–193; subcaudals 67–78 ...... *Boulengerina.*

Scales more or less oblique, sometimes very slightly; ventrals 141–172; subcaudals 13–25 .... *Elapechis.*

Scales oblique; ventrals 180–228; subcaudals 50–72 .... *Naja.*

B. Head long, narrow; snout not broader than long; body slightly compressed; scales very oblique; ventrals 202–270; subcaudals 97–121 .... *Dendraspis.*

1. Hydrus.

Schneid. Hist. Amph. i. p. 233; Bouleng. Cat. Sn. iii. p. 266.

1. Hydrus platurus.

Anguis platura Linn. S. N. i. p. 391.
Hydrus platurus Bouleng. t. c. p. 267.
Indian and Pacific Oceans.

2. Boulengerina.

Dollo, Bull. Mus. Belg. iv. 1886, p. 159; Bouleng. Cat. Sn. iii. p. 357.

1. Boulengerina stormsi Dollo, l. c.; Bouleng. l. c.
Lake Tanganyika.

3. Elapechis.

Bouleng. Cat. Sn. iii. p. 358.

Synopsis of the Species.

Scales in 13 rows; internasals much shorter than the præfrontals..	*E. guentheri.*
Scales in 13 rows; internasals three fourths the length of the præfrontals	*E. niger.*
Scales in 15 rows: internasals hardly half as long as the præfrontals	*E. boulengeri.*

1. Elapechis guentheri.

Elapsoidea guentheri Bocage, Jorn. Sc. Lisb. i. 1866, p. 70, pl. i. fig. 3.
Elapechis guentheri Bouleng. t. c. p. 359.
Tropical Africa, from the Gaboon and Uganda to Angola and Nyassaland.

2. Elapechis niger.

Elapsoidea nigra Günth. Ann. & Mag. N. H. (6) i. 1888, p. 332.
Elapechis niger Bouleng. l. c. pl. xx. fig. 1.
East Africa, Congo, N. Rhodesia.

3. Elapechis boulengeri.

Elapsoidea boulengeri Boettg. Zool. Anz. 1895, p. 62.
Elapechis boulengeri Bouleng. t. c. p. 361.
Zambesi.

4. Naia.

Laur. Syn. Rept. p. 90; Bouleng. Cat. Sn. iii. p. 372.

Synopsis of the Species.

Sixth (rarely seventh) upper labial largest and deepest; eye separated from the upper labials by suboculars; a single anterior temporal	***N. haie.***
Sixth upper labial largest and deepest, in contact with lower postocular, third and fourth entering the eye; a single anterior temporal	***N. melanoleuca.***
Third upper labial deepest, sixth not in contact with postocular, third or third and fourth entering the eye; 2 or 3 superposed anterior temporals	***N. nigricollis.***

1. NAIA HAIE.

Coluber haie Linn. in Hasselq. Reise Palest. p. 366.
Naia haie Bouleng. t. c. p. 374.

Borders of the Sahara, East Africa southwards to the Transvaal and Zululand; Palestine, Arabia.

2. NAIA MELANOLEUCA.

Naia haie, var. *melanoleuca* Hallow. Proc. Ac. Philad. 1857, pp. 61 & 72.
Naia melanoleuca Bouleng. t. c. p. 376.

Tropical Africa, from Uganda and the Gold Coast to Nyassaland and Angola.

3. NAIA NIGRICOLLIS Reinh. Vid. Selsk. Skrift. x. 1843, p. 269, pl. iii. figs. 5–7; Bouleng. t. c. p. 387.

Senegambia and Upper Egypt to Bechuanaland and Natal.

5. DENDRASPIS.

Schleg. Versl. Zool. Gen. Amsterd. 1848; Bouleng. Cat. Sn. iii. p. 434.

Synopsis of the Species.

A large upper temporal, in contact with the whole outer border of the parietal; scales in 15 to 19 rows	*D. jamesonii.*
Two upper temporals, in contact with the outer border of the parietal, the second separated from its fellow on the other side by 3 or more scales or shields; scales in 19 to 23 rows	*D. angusticeps.*
Two upper temporals, in contact with the outer border of the parietal, the second separated from its fellow on the other side by a single shield; scales in 19 rows	*D. sjoestedti.*

1. DENDRASPIS JAMESONII.

Elaps jamesonii Traill, in Schleg. Phys. Serp., Engl. Transl. p. 179, pl. ii. figs. 19 & 20.
Dendraspis jamesonii Bouleng. t. c. p. 436.

Tropical Africa, from Uganda and Nigeria to the Congo and Angola.

2. DENDRASPIS ANGUSTICEPS.

Naia angusticeps A. Smith, Ill. Zool. S. Afr., Rept. pl. lxx.
Dendraspis angusticeps Bouleng. t. c. p. 437.

East and Central Africa, Angola, South Africa.

3. DENDRASPIS SJOESTEDTI Lönnb. Wiss. Ergebn. Exped. Kilimandj.-Meru, Rept. p. 17.

British East Africa.

Perhaps based on an aberrant specimen of the preceding species.

Family VIPERIDÆ.

Synopsis of the Genera.

I. Eye moderate or large, separated from the upper labials by suboculars; ventrals less than 180.	
Upper surface of head covered with large symmetrical shields; pupil round	*Causus.*
Upper surface of head covered with scales; nasal in contact with rostral or separated by a single (naso-rostral) shield; pupil vertical; subcaudals in two rows	*Vipera.*
Upper surface of head covered with scales; nasal separated from the rostral by small scales; pupil vertical; subcaudals in two rows.	*Bitis.*
Upper surface of head covered with scales; pupil vertical; subcaudals single; tail prehensile	*Atheris.*
II. Eye minute, with round pupil; upper surface of head covered with large symmetrical shields; no loreal; a small præocular usually present; ventrals 178–356	*Atractaspis.*

1. CAUSUS.

Wagl. Syst. Amph. p. 172; Bouleng. Cat. Sn. iii. p. 465.

Synopsis of the Species.

I. Scales in 17 rows or more; subcaudals all or greater part in two rows.	
Snout obtuse, moderately prominent; ventrals 120–155	*C. rhombeatus.*
Snout prominent, often more or less distinctly turned up at the end; scales in 19 to 22 rows; ventrals 134–152	*C. resimus.*
Snout prominent, more or less turned up at the end; scales in 17 rows; ventrals 110–125	*C. defilippii.*
II. Scales in 15 rows; subcaudals single	*C. lichtensteinii.*

1. CAUSUS RHOMBEATUS.

Sepedon rhombeatus Licht. Verz. Doubl. Mus. Berl. p. 106.
Causus rhombeatus Bouleng. t. c. p. 467.

Tropical and South Africa.

2. CAUSUS RESIMUS.

Heterophis resimus Peters, Mon. Berl. Ac. 1862, p. 277, pl. —, fig. 4.
Causus resimus Bouleng. t. c. p. 468.

East and Central Africa, Angola.

3. CAUSUS DEFILIPPII.

Heterodon defilippii Jan, Arch. Zool. Anat. Phys. ii. 1862, p. 225.
Causus defilippii Bouleng. t. c. p. 469.

East and Central Africa, S. Rhodesia, Transvaal.

4. CAUSUS LICHTENSTEINII.

Aspidelaps lichtensteinii Jan, Rev. et Mag. Zool. 1859, p. 511.
Causus lichtensteinii Bouleng. t. c. p. 470.

Tropical Africa, from the Gold Coast and Uganda to the Congo.

2. Vipera.

Laur. Syn. Rept. p. 99; Bouleng. Cat. Sn. iii. p. 471.

Two species:—

No supraocular; anterior nasal separated from the rostral by a naso-rostral	*V. hindii.*
A large supraocular; anterior nasal in contact with the rostral .	*V. superciliaris.*

1. **Vipera hindii** Bouleng. Ann. & Mag. N. H. (8) v. 1910, p. 513.

Kenya district, East Africa.

2. **Vipera superciliaris** Peters, Mon. Berl. Ac. 1854, p. 625, and Reise Mossamb. iii. p. 144, pl. xxi.; Bouleng. Cat. Sn. iii. p. 491.

German East Africa at Cape Delgado.

3. Bitis.

Gray, Zool. Miscell. p. 69; Bouleng. Cat. Sn. iii. p. 492.

Synopsis of the Species.

One or two series of scales between the nasal and the rostral; nostrils directed upwards	*B. arietans.*
4 or 5 series of scales between the nasal and the rostral; a single enlarged, sometimes horn-like scale above the internasal, in contact with its fellow	*B. gabonica.*
4 or 5 series of scales between the nasal and the rostral; 2 or 3 enlarged, horn-like scales above the internasal, usually with small scales between them and their fellows .	*B. nasicornis.*

1. **Bitis arietans.**

Vipera arietans Merr. Tent. p. 152.
Bitis arietans Bouleng. t. c. p. 493.
Tropical and South Africa; Southern Arabia.

2. **Bitis gabonica.**

Echidna gabonica Dum. & Bibr. Erp. Gén. vii. p. 1428, pl. lxxx. *b*.
Bitis gabonica Bouleng. t. c. p. 499.
Tropical Africa.

3. **Bitis nasicornis.**

Coluber nasicornis Shaw, Nat. Miscell. iii. pl. xciv.
Bitis nasicornis Bouleng. t. c. p. 500.
Tropical Africa.

4. ATHERIS.

Cope, Proc. Ac. Philad. 1862, p. 337; Bouleng. Cat. Sn. iii. p. 508.

Synopsis of the Species.

No horn-like superciliary scales; scales in 15 to 25 rows; gular scales strongly keeled ...	*A. squamiger.*
No horn-like superciliary scales; scales in 25 to 32 rows; gular scales smooth or very feebly keeled ...	*A. nitschei.*
Several erect, horn-like superciliary scales; scales in 25 rows ...	*A. ceratophorus.*

1. **ATHERIS SQUAMIGER.**

Echis squamigera Hallow. Proc. Ac. Philad. 1854, p. 193.
Atheris squamiger Bouleng. t. c. p. 509.

Uganda, Central Africa, West Africa from Calabar to Angola.

2. **ATHERIS NITSCHEI** Tornier, Zool. Jahrb., Syst. xv. 1902, p. 589, fig.

Atheris woosnami Bouleng. Ann. & Mag. N. H. (7) xviii. 1906, p. 37, and Tr. Zool. Soc. xix. 1909, p. 246, pl. ix.

N.W. and E. of Lake Tanganyika, and Mt. Ruwenzori.

3. **ATHERIS CERATOPHORUS** Werner, Verh. Zool. bot. Ges. Wien, xlv. 1895, p. 194, pl. v. fig. 1; Bouleng. Cat. Sn. iii. p. 510.

German East Africa and Togoland.

5. ATRACTASPIS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 510.

Synopsis of the Species.

I. Anal divided; all or most of the subcaudals paired; scales in 23 to 27 rows.	
Snout rounded; one postocular; third lower labial largest	*A. irregularis.*
Snout pointed; one postocular; third lower labial largest . ..	*A. conradsi.*
Snout rounded; two postoculars; fourth or fifth lower labial largest ...	*A. bipostocularis.*
II. Anal entire; all or most of the subcaudals single.	
A. Postocular in contact with a large temporal.	
Snout cuneiform; first lower labial in contact with its fellow behind the symphysial; scales in 23 rows; ventrals 227–248 ...	*A. rostrata.*
Snout rounded; first lower labial in contact with its fellow behind the symphysial; scales in 19 or 21 rows; ventrals 251–300 ...	*A. aterrima.*
Snout rounded; symphysial in contact with the chin-shields; scales in 25 rows; ventrals 242 ...	*A. katangæ.*
B. Temporals small, 2 or 3 superposed in front; snout subcuneiform; scales in 29 to 37 rows; ventrals 212–245.	*A. microlepidota.*

1. ATRACTASPIS IRREGULARIS.

Elaps irregularis Reinh. Vid. Selsk. Skrift. x. 1843, p. 264, pl. iii. figs 1–3.

Atractaspis irregularis Bouleng. t. c. p. 513.

From the Gold Coast and Uganda to the Congo.

2. ATRACTASPIS CONRADSI Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 94.

Uganda and German East Africa.

3. ATRACTASPIS BIPOSTOCULARIS Bouleng. Ann. & Mag. N. H. (7) xv. 1905, p. 190.

Mount Kenya.

4. ATRACTASPIS ROSTRATA Gunth. Ann. & Mag. N. H. (4) i. 1868, p. 429, pl. xix. fig. i.; Bouleng. Cat. Sn. iii. p. 514.

East Africa and Nyassaland.

5. ATRACTASPIS ATERRIMA Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 363; Bouleng. t. c. p. 515.

Uganda and West Africa, from the Gold Coast to the Niger.

6. ATRACTASPIS KATANGÆ Bouleng. Ann. Mus. Congo, Zool. ii. 1901, p. 13, pl. v. fig. 2; Sternf. Mitth. Zool. Mus. Berl. v. 1911, p. 385.

Katanga and German East Africa.

7. ATRACTASPIS MICROLEPIDOTA Gunth. Ann. & Mag. N. H. (3) xviii. 1866, p. 29, pl. vii.; Bouleng. Cat. Sn. iii. p. 517.

East and Central Africa.

46. A List of the Snakes of North-East Africa, from the Tropic to the Soudan and Somaliland, including Socotra. By G. A. BOULENGER, F.R.S., F.Z.S.*

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With this list the Ophidian fauna of East and Central Africa is completed, only two divisions remaining to be dealt with, viz., West Africa north of the Congo, and North Africa.

Synopsis of the Families.

I. Worm-like, with small inferior mouth; eyes hidden or visible under the head-shields, and body covered with uniform imbricate scales above and beneath.

22 or more scales round middle of body; ocular not bordering the mouth; tail not or but little longer than broad	TYPHLOPIDÆ.
14 scales round middle of body	GLAUCONIIDÆ.

II. Mouth large, eyes exposed; body with enlarged shields beneath (except in the marine genus *Hydrus*).

Ventral shields much narrower than the body; supraocular, if distinct, broken up into two or more shields; scales on anterior part of body smooth	BOIDÆ.
Ventral shields at least nearly as broad as the body; supraocular single; poison-fangs, if present, not in a very large sheath	COLUBRIDÆ.
Ventral shields at least nearly as broad as the body, or upper surface of head covered with small scales; poison-fangs in a very large sheath below the eye	VIPERIDÆ.

Family TYPHLOPIDÆ.

A single genus.

1. TYPHLOPS.

Schneid. Hist. Amph. ii. p. 339; Bouleng. Cat. Sn. i. p. 7.

Synopsis of the Species.

I. Snout rounded or with obtusely angular horizontal edge.

A. Rostral not more than one-third width of head; eyes distinct.

Snout rounded; 24 scales round middle of body, the diameter of which is 37 to 50 times in total length	*T. socotranus.*
Snout much depressed; 22 scales round middle of body, the diameter of which is 20 to 30 times in total length	*T. cuneirostris.*

B. Rostral very broad.

Rostral half width of head; 30 scales round middle of body, the diameter of which is 30 to 40 times in total length	*T. blanfordii.*
Rostral more than half width of head; 26 to 30 scales round middle of body, the diameter of which is 24 to 30 times in total length	*T. punctatus.*

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II. Snout with sharp horizontal edge.

No subocular; 28 scales round middle of body, the diameter of which is 55 times in total length .... *T. acutirostris*

No subocular; 24 scales round middle of body, the diameter of which is 90 times in total length .... *T. somalicus*

A large subocular, separating the small ocular from the upper labials; 24 scales round middle of body, the diameter of which is 50 to 63 times in total length .... *T. unitæni*

1. TYPHLOPS SOCOTRANUS Bouleng. Ann. & Mag. N. H. (6) iv. 1889, p. 362, and Cat. Sn. i. p. 21, pl. ii. fig. 2.

Socotra.

2. TYPHLOPS CUNEIROSTRIS Peters, Mon. Berl. Ac. 1879, p. 775, pl. —, fig. 4; Bouleng. Cat. Sn. i. p. 32, and Ann. Mus. Genova (2) xvii. 1896, p. 10.

Somaliland.

3. TYPHLOPS BLANFORDII Bouleng. Ann. & Mag. N. H. (6) iv. 1889, p. 363, and Cat. Sn. i. p. 39; Peracca, Boll. Mus. Torin. xii. no. 273, p. 1.

Abyssinia, Erythrea.

4. TYPHLOPS PUNCTATUS Leach.

Bouleng. Cat. Sn. i. p. 42.

Typhlops adolphi Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 70.

Tropical Africa, as far north as the Gambia and the Bahr el Gebel; not recorded from Somaliland.

5. TYPHLOPS ACUTIROSTRIS Mocquard, Bull. Mus. Paris, 1905, p. 77.

Shoa.

6. TYPHLOPS SOMALICUS Bouleng. Proc. Zool. Soc. 1895, p. 536, pl. xxx. fig. 1, and Cat. Sn. iii. p. 589.

Somaliland.

7. TYPHLOPS UNITÆNIATUS Peters, Mon. Berl. Ac. 1878, p. 205, pl. ii. fig. 5; Bouleng. Cat. Sn. i. p. 55, and Ann. Mus. Genova (3) v. 1912, p. 331 (var. *atæniatus*).

Somaliland and British East Africa.

Family GLAUCONIIDÆ.

A single genus.

1. GLAUCONIA.

Gray, Cat. Liz. p. 139; Bouleng. Cat. Sn. i. p. 59.

Synopsis of the Species.

I. Ocular bordering the mouth.

A. Snout more or less strongly hooked in profile.

Rostral extending posteriorly to the level of the eyes; diameter of body 70 to 113 times in total length .... *G. macrorhynchus.*

Rostral not extending to the level of the eyes; diameter of body 100 to 140 times in total length .... *G. filiformis.*
Rostral not extending to the level of the eyes; diameter of body 40 to 48 times in total length .. .. *G. macrura.*

B. Snout not hooked.

Supraocular nearly twice as broad as long; diameter of body 50 to 55 times in total length .... *G. emini.*
Supraocular small, longer than broad; diameter of body 38 times in total length .... *G. reticulata.*
Supraocular small, not or but little broader than long; diameter of body 65 to 90 times in total length . . .. *G. cairi.*

II. Ocular not bordering the mouth; diameter of body 42 times in total length ... . *G. dissimilis.*

1. GLAUCONIA MACRORHYNCHUS.

Stenostoma macrorhynchum Jan, Arch. Zool. Anat. Phys. i. 1862, p. 190.
Glauconia macrorhynchus Bouleng. Cat. Sn. i. p. 61.
Glauconia algeriensis Jacquet, Bibl. Anat. iv. 1896, p. 79, figs.

Nubia, Algeria, Mesopotamia (?), Persia.

2. GLAUCONIA FILIFORMIS Bouleng. Bull. Liverp. Mus. ii. 1899, p. 7, and Rep. Sokotra Exped. p. 88, pl. xi. fig. 2.

Socotra.

3. GLAUCONIA MACRURA Bouleng. Rep. Sokotra Exped. p. 89, pl. xi. fig. 3.

Socotra.

4. GLAUCONIA EMINI Bouleng. Ann. & Mag. N. H. (6) vi. 1890, p. 91, and Cat. Sn. i. p. 64, pl. iii. fig. 8.

Central and East Africa, as far north as Somaliland and Abyssinia.

5. GLAUCONIA RETICULATA Bouleng. Ann. & Mag. N. H. (7) xviii. 1906, p. 441.

Goolis Mts., Somaliland.

6. GLAUCONIA CAIRI.

Stenostoma cairi Dum. & Bibr. Erp. Gén. vi. p. 323.
Glauconia cairi Bouleng. Cat. Sn. i. p. 66.

Egypt, Nubia, Abyssinia, Somaliland, Mauritania.

7. GLAUCONIA DISSIMILIS.

Stenostoma dissimile Bocage, Jorn. Sc. Lisb. xi. 1886, p. 174.
Glauconia dissimilis Bouleng. t. c. p. 70.

White Nile.

Family BOIDÆ.

Two genera:—

Upper surface of head with shields; rostral and anterior upper labials deeply pitted; subcaudals in two rows .... *Python.*
Upper surface of head with small scales; tail very short, subcaudals single.......... .... *Eryx.*

1. PYTHON.

Daud. Hist. Rept. v. p. 266; Bouleng. Cat. Sn. i. p. 85.

Two species:—

Two upper labials pitted; 79–95 scales across thickest part of body; ventrals 260–286; subcaudals 58–82	*P. sebæ.*
Four upper labials pitted; 58–63 scales across thickest part of body; ventrals 196–207; subcaudals 30–37	*P. regius.*

1. PYTHON SEBÆ.

Coluber sebæ Gmel. S. N. i. p. 1118.

Python sebæ Bouleng. t. c. p. 86.

Tropical and South Africa, as far north as Senegambia and the White Nile.

2. PYTHON REGIUS.

Boa regia Shaw, Zool. iii. p. 347, pl. xcvi.

Python regius Bouleng. t. c. p. 88.

Senegambia to Niger, eastwards to the Egyptian Soudan.

2. ERYX.

Daud. Hist. Rept. vii. p. 251; Bouleng. Cat. Sn. i. p. 122.

Two species:—

Tail ending in a conical scute; scales in 47 to 53 rows, keeled on posterior part of body	*E. thebaicus.*
Tail ending in a curved, claw-like scute; scales in 41 to 45 rows, all smooth	*E. muelleri.*

1. ERYX THEBAICUS Reuss, Mus. Senckenb. i. 1834, p. 134; Bouleng. t. c. p. 125.

Upper Egypt to German East Africa.

2. ERYX MUELLERI.

Gongylophis muelleri Bouleng. Ann. & Mag. N. H. (6) ix. 1892, p. 74.

Eryx muelleri Bouleng. Cat. Sn. i. p. 128, pl. v. fig. 2.

Egyptian Soudan, Mauritania, N. Nigeria, Togoland.

Family COLUBRIDÆ.

Three parallel series:—

No poison-fangs; all the teeth solid	A. Aglypha.
Poison-fangs behind	B. Opisthoglypha.
Poison-fangs in front	C. Proteroglypha.

A. Aglypha.

I. Nostril between two nasals, or between two nasals and the internasal; loreal present.

A. At least one upper labial bordering the eye.

1. Pupil round; scales in 19 or 21 rows; no subocular; a single anterior temporal.

Scales in 19 rows; ventrals 131–150; anal divided; subcaudals 55–95 .... *Tropidonotus.*

Scales in 21 rows; ventrals 174–198; anal entire; subcaudals 36–41; a deep groove above 5th and 6th upper labials.......... *Pseudoboodon.*

2. Pupil vertically elliptic.

a. Anal entire; a single anterior temporal.

Scales smooth, in 21–33 rows .... *Boodon.*

Scales smooth, in 17 rows .... *Lycophidium.*

Scales strongly keeled, vertebrals bicarinate .... *Simocephalus.*

b. Anal divided.

Scales in 21 rows; ventrals 216; subcaudals 67–70 .... *Aeluroglena.*

Scales in 19 rows; ventrals 160–188; subcaudals 35–46; rostral angularly bent, detached at the sides .... *Lytorhynchus.*

3. Pupil round; scales in 15–23 rows; ventrals 150 or more, or, if less, subcaudals 100 or more; loreal not more than twice as long as deep.

a. One or two suboculars below the præocular; frontal not twice as long as broad .... *Zamenis.*

b. No subocular; frontal not twice as long as broad.

Scales in 15 rows; ventrals 150–193; subcaudals 77–123, without a keel .... *Chlorophis.*

Scales in 15 rows; ventrals 166–207; subcaudals 112–157, with a strong keel .... *Philothamnus.*

Scales in 21 rows; ventrals 176–224; subcaudals 63–88 .... *Coronella.*

c. No subocular; frontal at least twice as long as broad; scales in 15 rows; ventrals 130–143; subcaudals 100–128 .... *Grayia.*

B. Eye separated from the upper labials by a series of suboculars; snout with angular horizontal edges; scales in 19–25 rows .... *Scaphiophis.*

II. Nostril in a single or semidivided nasal.

B. Scales smooth, in 15 rows.

1. Nasal semidivided, with a longitudinal cleft behind the nostril; internasal and præfrontal single.

Rostral with angular horizontal edge .... *Prosymna.*

Rostral with obtuse horizontal edge .... *Asthenophis.*

2. Nasal entire; internasal and præfrontal paired.

Ventrals 162; anal divided; subcaudals 69 .... *Contia.*

Ventrals 113–144; anal entire; subcaudals 19–46 .... *Homalosoma.*

B. Scales strongly keeled, in 23–27 rows; no loreal .... *Dasypeltis.*

1. TROPIDONOTUS.

Kuhl, Bull. Sc. Nat. ii. 1824, p. 81; Bouleng. Cat. Sn. i. p. 192.

1. TROPIDONOTUS OLIVACEUS.

Coronella olivacea Peters, Mon. Berl. Ac. 1854, p. 622.

Tropidonotus olivaceus Bouleng. t. c. p. 227.

Tropical Africa, from the Soudan to Angola, Damaraland, and Southern Rhodesia.

2. PSEUDOBOODON.

Peracca, Boll. Mus. Torin. xii. 1897, no. 273, p. 1.

1. PSEUDOBOODON GASCÆ.

Peracca, t. c. p. 2, fig.

Lamprophis abyssinicus Mocquard, Bull. Mus. Paris, 1906, p. 249.

Erythrea, Abyssinia.

3. Boodon.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 460; Bouleng. Cat. Sn. i. p. 327.

Synopsis of the Species.

I. Scales in 21 or 23 rows; præocular not extending to upper surface of head.

Three upper labials entering the eye; a single anterior temporal . *B. lemniscatus.*
Two upper labials entering the eye; 2 or 3 superposed anterior temporals .... *B. erlangeri.*

II. Scales in 25 to 33 rows; præocular extending to upper surface of head.

Parietals longer than the distance between the frontal and the end of the snout .... *B. lineatus.*
Parietals as long as the distance between the frontal and the end of the snout .... *B. fuliginosus.*

1. **Boodon lemniscatus** Dum. & Bibr. Erp. Gén. vii. p. 365; Bouleng. t. c. p. 329.

Lamprophis rogeri Mocquard, Bull. Mus. Paris, 1904, p. 307, and 1905, p. 289.

Abyssinia.

2. **Boodon erlangeri** Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 92.

Somaliland.

3. **Boodon lineatus** Dum. & Bibr. Erp. Gén. vii. p. 363; Bouleng. t. c. p. 332.

Tropical and South Africa; S. Arabia.

4. **Boodon fuliginosus.**

Lycodon fuliginosus Boie, Isis, 1827, p. 551.

Boodon fuliginosus Bouleng. t. c. p. 334.

Mauritania to N. Nigeria, eastwards to the Egyptian Soudan.

4. Lycophidium.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 462; Bouleng. Cat. Sn. i. p. 336.

Two species:—

Rostral nearly twice as broad as deep .... *L. capense.*
Rostral but little broader than deep .... *L. abyssinicum.*

1. **Lycophidium capense.**

Lycodon capensis A. Smith, S. Afr. Quart. Journ. i. no. 5, 1831, p. 18.

Lycophidium capense Bouleng. t. c. p. 339.

Tropical and South Africa.

2. **Lycophidium abyssinicum** Bouleng. t. c. p. 342, pl. xxii. fig. 1.

Abyssinia.

5. SIMOCEPHALUS.

Günth. Cat. Col. Sn. p. 194; Bouleng. Cat. Sn. iii. p. 344.

1. SIMOCEPHALUS BUTLERI Bouleng. Ann. & Mag. N. H. (7) xx. 1907, p. 489, and Ann. Mus. Genova (3) v. 1911, p. 164.

Mehelya somaliensis Lönnb. & Anderss. Ark. f. Zool. viii. 1913, no. 2, p. 2.

Egyptian Soudan, Southern Ethiopia, Somaliland.

6. ZAMENIS.

Wagl. Syst. Amph. p. 188; Bouleng. Cat. Sn. i. p. 379.

Synopsis of the Species.

I. Scales in 15 rows; ventrals 173	*Z. somalicus.*
II. Scales in 19 rows.	
Ventrals 213–262; subcaudals 113–154	*Z. rhodorhachis.*
Ventrals 159; subcaudals 70	*Z. brevis.*
III. Scales in 21 (rarely 23) rows; two labials entering the eye.	
9 or 10 upper labials; ventrals 171–187	*Z. smithii.*
9 upper labials; ventrals 200–228	*Z. florulentus.*
8 upper labials; ventrals 195	*Z. citernii.*
IV. Scales in 23 rows; a single labial entering the eye; ventrals 219–228	*Z. socotræ.*

1. ZAMENIS SOMALICUS Bouleng. Ann. Mus. Genova (2) xvii. 1896, p. 11.

Somaliland.

2. ZAMENIS RHODORHACHIS Jan, in De Filippi, Viagg. Pers. p. 356; Bouleng. Cat. Sn. i. p. 398.

Egypt to Somaliland; S.W. Asia.

3. ZAMENIS BREVIS Bouleng. Ann. Mus. Genova (2) xv. 1895, p. 13, pl. iii. fig. 3, and Cat. Sn. iii. p. 623.

Somaliland.

4. ZAMENIS SMITHII Bouleng. P. Z. S. 1895, p. 536, pl. xxx. fig. 2, and Cat. Sn. iii. p. 624.

Somaliland.

5. ZAMENIS FLORULENTUS.

Coluber florulentus Geoffr. Descr. Égypte, Rept. p. 146, pl. viii. fig. 2.

Zamenis florulentus Bouleng. Cat. Sn. i. p. 402.

Egypt to Somaliland.

6. ZAMENIS CITERNII Bouleng. Ann. Mus. Genova (3) v. 1912, p. 331.

Somaliland.

7. Zamenis socotræ Günth. P. Z. S. 1881, p. 463, pl. xli.; Bouleng. Cat. Sn. i. p. 408.
Socotra.

7. Aeluroglena.

Bouleng. Ann. & Mag. N. H. (7) ii. 1898, p. 132.

1. Aeluroglena cucullata Bouleng. l. c.
Somaliland.

8. Lytorhynchus.

Peters, Mon. Berl. Ac. 1862, p. 272; Bouleng. Cat. Sn. i. p. 414.

1. Lytorhynchus diadema.

Heterodon diadema Dum. & Bibr. Erp. Gén. vii. p. 779.
Lytorhynchus diadema Bouleng. t. c. p. 415.
Algerian and Tunisian Sahara, Tripoli, Egypt, Nubia; Arabia, Syria.

9. Chlorophis.

Hallow. Proc. Ac. Philad. 1857, p. 52; Bouleng. Cat. Sn. ii. p. 91.

Two species:—

3 labials entering the eye: ventrals 151-193, without lateral keels ... *C. emini.*
2 labials entering the eye; ventrals 148-169, with a slight lateral keel .... *C. neglectus.*

1. Chlorophis emini.

Ahætulla emini Günth. Ann. & Mag. N. H. (3) xi. 1863, p. 285.
Chlorophis emini Bouleng. t. c. p. 92, pl. v. fig. 1.
Egyptian Soudan to Uganda and Ruwenzori.

2. Chlorophis neglectus.

Philothamnus neglectus Peters, Mon. Berl. Ac. 1866, p. 890.
Chlorophis neglectus Bouleng. t. c. p. 94.
Central and East Africa, as far north as Somaliland.

10. Philothamnus.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. ii. p. 98.

1. Philothamnus semivariegatus A. Smith, op. cit. pls. lix., lx., & lxiv. fig. 1; Bouleng. t. c. p. 99.
Tropical and South Africa.

11. Coronella.

Laur. Syn. Rept. p. 84; Bouleng. Cat. Sn. ii. p. 188.

1. Coronella semiornata Peters, Mon. Berl. Ac. 1856, p. 622; Bouleng. t. c. p. 195.

N. Rhodesia and E. Africa, as far north as the Blue Nile.

12. Grayia.

Günth. Cat. Col. Sn. p. 50; Bouleng. Cat. Sn. ii. p. 286.

1. Grayia tholloni Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 11; Bouleng. P. Z. S. 1909, p. 951, fig.

Egyptian Soudan, Uganda, Katanga, French Congo.

13. Scaphiophis.

Peters, Mon. Berl. Ac. 1870, p. 644; Bouleng. Cat. Sn. ii. p. 254.

1. Scaphiophis albopunctatus Peters, t. c. p. 645, pl. i. fig. 4; Bouleng. l. c.

Tropical Africa, from the Soudan to the Congo.

14. Prosymna.

Gray, Cat. Sn. p. 80; Bouleng. Cat. Sn. ii. p. 246.

1. Prosymna meleagris.

Calamaria meleagris Reinh. Vid. Selsk. Afh. x. 1843, p. 238, pl. i. figs. 4–6.

Prosymna meleagris Bouleng. t. c. p. 249.

Egyptian Soudan and Sierra Leone to the Congo.

15. Asthenophis.

Bouleng. Ann. Mus. Genova (2) xvii. 1896, p. 12.

1. Asthenophis ruspolii Bouleng. l. c.

Somaliland.

16. Contia.

Baird & Gir. Cat. N. Am. Rept. p. 110; Bouleng. Cat. Sn. ii. p. 255.

1. Contia africana Bouleng. Ann. & Mag. N. H. (8) xiv. 1914, p. 483.

Red Sea Province of the Soudan.

17. HOMALOSOMA.

Wagl. Syst. Amph. p. 190; Bouleng. Cat. Sn. ii. p. 273.

1. HOMALOSOMA LUTRIX.

Coluber lutrix Linn. S. N. i. p. 375.
Homalosoma lutrix Bouleng. t. c. p. 274.
Homalosoma shiranum et *abyssinicum* Bouleng. t. c. p. 276, pl. xiii. figs. 1 & 2.

East, Central, and South Africa, as far north as Abyssinia.

18. DASYPELTIS.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. ii. p. 353.

1. DASYPELTIS SCABRA.

Coluber scaber Linn. Mus. Ad. Frid. p. 36, pl. x. fig. 1.
Dasypeltis scabra Bouleng. t. c. p. 354.

Tropical and South Africa, Egypt; South Arabia.

B. Opisthoglypha.

I. Eye rather small, moderate, or large, with vertically elliptic or subelliptic pupil; loreal present; nasal, if not completely divided into two, with horizontal cleft.
A. Nostril between two nasals.
Scales in 21 or 23 rows; ventrals 142–153; subcaudals single, 35–44 .... *Ditypophis.*
Scales in 19 to 23 rows; ventrals 205–274; subcaudals 61–86 pairs .... *Tarbophis.*
Scales in 19 rows; ventrals 144–180; subcaudals 32–54 pairs .. *Leptodira.*
B. Nasal semidivided; scales in 17 (rarely 19) rows; ventrals 148–173; 187; subcaudals 61–78 .... *Hemirhagerrhis.*
II. Eye moderate or large, with round or horizontal pupil; loreal present.
A. Pupil round.
1. Loreal not more than once and a half as long as deep; scales not oblique.
a. Nostril round; scales in 17 rows.
Nostril in a semidivided nasal; rostral broader than deep, just visible from above .... *Amplorhinus.*
Nostril between two nasals and the internasal; rostral as deep as broad, its upper portion at least half as long as its distance from the frontal .... *Trimerorhinus.*
b. Nostril a crescentic slit in a divided or semidivided nasal; scales in 17 or 19 rows.
Subcaudals less than 80 .... *Cœlopeltis.*
Subcaudals 90 or more .... *Rhamphiophis.*
2. Loreal at least once and a half as long as deep; scales more or less oblique; subcaudals 78 or more.
Scales in 17 rows; a single anterior temporal .... *Dromophis.*
Scales in 13 to 19 rows; usually two superposed anterior temporals; one or two anterior maxillary teeth much enlarged, fang-like .... *Psammophis.*
3. Loreal not more than once and a half as long as deep; nostril in an undivided nasal; scales very narrow, very oblique, keeled, in 19 or 21 rows .... *Dispholidus.*
B. Pupil horizontal; nostril in an undivided nasal; scales narrow, oblique, feebly keeled, in 19 rows .... *Thelotornis.*

III. Eye small or very small; no loreal; nasal, if present, single; scales in 15 rows.

A. Subcaudals paired; ventrals 171–256.

Nasal and internasals present .... *Micrelaps.*
No nasal or internasals; nostril in the first upper labial .... *Chilorhinophis.*

B. Subcaudals single.

Internasal in contact with first upper labial; ventrals 104–115; subcaudals 11–13 .... *Brachyophis.*
Nasal in contact with rostral; ventrals 145–165; subcaudals 48–71 .... *Aparallactus.*

1. DITYPOPHIS.

Günth. P. Z. S. 1881, p. 462; Bouleng. Cat. Sn. iii. p. 46.

1. **DITYPOPHIS VIVAX** Günth. l. c. pl. xl.; Bouleng. l. c.
Socotra.

2. TARBOPHIS.

Fleischm. Dalm. nov. Serp. Gen. p. 17; Bouleng. Cat. Sn. iii. p. 47.

Two species:—

Scales in 19 or 21 rows; anal entire .... *T. guentheri.*
Scales in 21 or 23 rows; anal divided .... *T. obtusus.*

1. **TARBOPHIS GUENTHERI** Anders. P. Z. S. 1895, p. 656, pl. xxxvi. fig. 3; Bouleng. t. c. p. 52.
East Africa, as far north as Somaliland; Arabia, Syria.

2. **TARBOPHIS OBTUSUS.**
Coluber obtusus Reuss, Mus. Senckenb. i. 1834, p. 137.
Tarbophis obtusus Bouleng. l. c.
Egypt to Somaliland, Mauritania and N. Nigeria.

3. LEPTODIRA.

Günth. Cat. Col. Sn. p. 165; Bouleng. Cat. Sn. iii. p. 88.

1. **LEPTODIRA HOTAMBŒIA.**
Coronella hotambœia Laur. Syn. Rept. p. 85.
Leptodira hotambœia Bouleng. t. c. p. 89.
Tropical and South Africa.

4. HEMIRHAGERRHIS.

Boettg. Zool. Anz. 1893, p. 119; Bouleng. Cat. Sn. iii. p. 119.

1. **HEMIRHAGERRHIS KELLERI** Boettg. t. c. p. 129; Bouleng. l. c.
Somaliland and British East Africa.

5. AMPLORHINUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 124.

1. AMPLORHINUS NOTOTÆNIA.

Coronella nototænia Günth. P. Z. S. 1864, p. 309, pl. xxvi. fig. 1.

Amplorhinus nototænia Bouleng. t. c. p. 125.

Amplorhinus güntheri Mocquard, Bull. Mus. Paris, 1906, p. 251.

Egyptian Soudan to Nyassaland; Angola.

6. TRIMERORHINUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 138.

1. TRIMERORHINUS TRITÆNIATUS.

Rhagerrhis tritæniata Günth. Ann. & Mag. N. H. (4) i. 1868, p. 423, pl. xix. fig. H.

Trimerorhinus tritæniatus Bouleng. t. c. p. 139.

Africa south of the Equator; East Africa as far north as Abyssinia.

Perhaps not specifically separable from *T. rhombeatus* L.

7. CŒLOPELTIS.

Wagl. Syst. Amph. p. 189; Bouleng. Cat. Sn. iii. p. 141.

1. CŒLOPELTIS MOILENSIS.

Coluber moilensis Reuss, Mus. Senckenb. i. p. 142, pl. vii. fig. 1.

Cœlopeltis moilensis Bouleng. t. c. p. 143.

Northern Sahara, from Algeria to Egypt and Nubia; Arabia, western Persia.

8. RHAMPHIOPHIS.

Peters, Mon. Berl. Ac. 1854, p. 624; Bouleng. Cat. Sn. iii. p. 144.

Two species:—

Scales in 19 rows on the body; ventrals 230–241; subcaudals 154–160	*R. rubropunctatus.*
Scales in 17 rows on the body; ventrals 148–192; subcaudals 90–110	*R. oxyrhynchus.*

1. RHAMPHIOPHIS RUBROPUNCTATUS.

Dipsina rubropunctata Fisch. Jahrb. Hamb. Wiss. Anst. i. 1884, p. 7, pl. i. fig. 3.

Rhamphiophis rubropunctatus Bouleng. t. c. p. 146.

Egyptian Soudan to Kilimanjaro.

2. **Rhamphiophis oxyrhynchus.**

Psammophis oxyrhynchus Reinh. Vid. Selsk. Skrift. x. 1843, p. 244, pl. i. figs. 10-12.

Rhamphiophis oxyrhynchus Bouleng. l. c.

Tropical Africa.

9. Dromophis.

Peters, Mon. Berl. Ac. 1869, p. 447; Bouleng. Cat. Sn. iii. p. 149.

1. **Dromophis lineatus.**

Dryophylax lineatus Dum. & Bibr. Erp. Gén. vii. p. 1124.

Dromophis lineatus Bouleng. l. c.

Coast of Guinea to Eastern Soudan, Central Africa.

10. Psammophis.

Boie, Isis, 1827, p. 521; Bouleng. Cat. Sn. iii. p. 152.

Synopsis of the Species.

I. Scales in 17 rows, rarely 19.	
Rostral a little broader than deep; 9 (rarely 8 or 10) upper labials, sixth shorter than eye; subcaudals 93-154	*P. schokari.*
Rostral a little broader than deep; 9 (rarely 8) upper labials, sixth (or fifth) as long as eye; subcaudals 130-178	*P. punctulatus.*
Rostral as deep as broad; 8 (rarely 9) upper labials; subcaudals 85-116	*P. sibilans.*
II. Scales in 15 rows	*P. biseriatus.*
III. Scales in 13 rows	*P. pulcher.*

1. **Psammophis schokari.**

Coluber schokari Forsk. Descr. Anim. p. 14.

Psammophis schokari Bouleng. t. c. p. 157.

North Africa to Mauritania and Somaliland; Arabia and Syria to Afghanistan and Sind.

2. **Psammophis punctulatus** Dum. & Bibr. Erp. Gén. vii. p. 897; Bouleng. t. c. p. 159.

East Africa, from the Blue Nile to Mozambique; Arabia.

3. **Psammophis sibilans.**

Coluber sibilans Linn. S. N. i. p. 383.

Psammophis sibilans Bouleng. t. c. p. 161.

Tropical and South Africa, Egypt.

4. **Psammophis biseriatus** Peters, Sitzb. Ges. Nat. Fr. Berl. 1881, p. 88; Bouleng. t. c. p. 168.

Somaliland and British East Africa.

5. Psammophis pulcher Bouleng. P. Z. S. 1895, p. 537, pl. xxx. fig. 3, and t. c. p. 169.

Somaliland.

11. Dispholidus.

Duvernoy, Ann. Sc. Nat. xxvi. 1832, p. 150; Bouleng. Cat. Sn. iii. p. 186.

1. Dispholidus typus.

Bucephalus typus A. Smith, Zool. Journ. iv. 1829, p. 441.
Dispholidus typus Bouleng. t. c. p. 187.

Tropical and South Africa.

12. Thelotornis.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 184.

1. Thelotornis kirtlandii.

Leptophis kirtlandii Hallow. Proc. Ac. Philad. 1844, p. 62.
Thelotornis kirtlandii Bouleng. t. c. p. 185.

Tropical and South Africa.

13. Micrelaps.

Boettg. Ber. Senckenb. Ges. 1879–80, p. 136; Bouleng. Cat. Sn. iii. p. 248.

Two species:—

3 upper labials entering the eye; ventrals 171 . . . . *M. vaillanti.*
2 upper labials entering the eye; ventrals 203–232 . . . *M. boettgeri.*

1. Micrelaps vaillanti.

Elaposchema vaillanti Mocquard, Mém. Cent. Soc. Philom. 1888, p. 123, pl. xii. fig. 1.
Micrelaps vaillanti Bouleng. t. c. p. 249.

Somaliland.

2. Micrelaps boettgeri Bouleng. Ann. Mus. Genova (2) xvii. 1896, p. 13.

Micrelaps nigriceps Sternf. Mitth. Zool. Mus. Berl. v. 1910, p. 69.

Somaliland, Abyssinia.

14. Chilorhinophis.

Werner, Sitzb. Ak. Wien, cxvi. i. 1908, p. 1881.

1. Chilorhinophis butleri Werner, l. c. pl. iii. fig. 8.

Egyptian Soudan.

15. BRACHYOPHIS.

Mocquard, Mém. Cent. Soc. Philom. 1888, p. 125; Bouleng. Cat. Sn. iii. p. 254.

1. BRACHYOPHIS REVOILI Mocquard, l. c. pl. xi. fig. 3; Bouleng. l. c.

Somaliland.

16. APARALLACTUS.

A. Smith, Ill. Zool. S. Afr., Rept., App. p. 15; Bouleng. Cat. Sn. iii. p. 255.

1. APARALLACTUS CONCOLOR.

Uriechis concolor Fisch. Jahrb. Hamb. Wiss. Anst. i. 1884, p. 4, pl. i. fig. 1.
Aparallactus concolor Bouleng. t. c. p. 257.

Lado, Uganda, Somaliland.

C. Proteroglypha.

(Loreal absent in all the genera.)

I. Tail compressed, oar-shaped, scales juxtaposed; no ventrals (Sea-snake)	*Hydrus.*
II. Tail cylindrical; scales imbricate; ventrals large.	
Head short, snout broader than long; scales oblique, 17-25 across middle of body, 21-29 across neck; anal entire	*Naia.*
Head short, snout broader than long; scales not oblique, 23 across middle of body, 27 across neck; anal divided	*Walterinnesia.*
Head long and narrow, snout not broader than long; scales very oblique, in 19 to 23 rows	*Dendraspis.*

1. HYDRUS.

Schneid. Hist. Amph. i. p. 233; Bouleng. Cat. Sn. iii. p. 266.

1. HYDRUS PLATURUS.

Anguis platura Linn. S. N. i. p. 391.
Hydrus platurus Bouleng. t. c. p. 267.

Indian and Pacific Oceans; E. Africa as far north as the coast of Obok.

2. NAIA.

Laur. Syn. Rept. p. 90; Bouleng. Cat. Sn. iii. p. 372.

Two species:—

Eye separated from the upper labials by suboculars; 6th or 7th upper labials largest and deepest	*N. haie.*
Third or third and fourth upper labials deepest and entering the eye.	*N. nigricollis.*

1. NAIA HAIE.

Coluber haie Linn. S. N. i. p. 387.
Naia haie Bouleng. t. c. p. 374.

Borders of the Sahara, East Africa southwards to the Transvaal and Zululand; Arabia, Palestine.

2. **NAIA NIGRICOLLIS** Reinh. Vid. Selsk. Skrift. x. 1843, p. 269, pl. iii. figs. 5–7; Bouleng. t. c. p. 378.

Senegambia and Upper Egypt to Bechuanaland and Natal.

3. WALTERINNESIA.

Lataste, Le Natur. 1887, p. 411; Bouleng. Cat. Sn. iii. p. 392.

1. **WALTERINNESIA ÆGYPTIA** Lataste, l. c.; Bouleng. l. c.

Nubia? Egypt?

4. DENDRASPIS.

Schleg. Versl. Zool. Gen. Amsterd. 1848; Bouleng. Cat. Sn. iii. p. 434.

Two species:

Second upper labial much deeper than first . *D. angusticeps.*
Second upper labial not deeper than first *D. antinorii.*

1. **DENDRASPIS ANGUSTICEPS.**

Naia angusticeps A. Smith, Ill. Zool. S. Afr., Rept. pl. lxx.
Dendraspis angusticeps Bouleng. t. c. p. 437.

East and Central Africa, Angola, South Africa.

2. **DENDRASPIS ANTINORII** Peters, Mon. Berl. Ac. 1873, p. 411, pl. i. fig. 2; Bouleng. l. c.

Abyssinia.

Family VIPERIDÆ.

Synopsis of the Genera.

I. Eye moderate or large, separated from the upper labials by suboculars.
  A. Upper surface of head covered with large symmetrical shields; loreal present; pupil round; ventrals 120–155 . *Causus.*
  B. Upper surface of head covered with scales; pupil vertical; scales strongly keeled; ventrals 130–205.
Lateral scales not smaller than dorsals, without serrated keels; subcaudals in two rows *Bitis.*
Lateral scales smaller than dorsals, oblique, with serrated keels; subcaudals in two rows ... ... *Cerastes.*
Lateral scales smaller than dorsals, oblique, with serrated keels; subcaudals single ... . *Echis.*
II. Eye minute, with round pupil; upper surface of head covered with large symmetrical shields; no loreal; ventrals 212–245. *Atractaspis.*

1. CAUSUS.

Wagl. Syst. Amph. p. 172; Bouleng. Cat. Sn. iii. p. 465.

Two species:—

Snout obtuse, moderately prominent; dorsal scales more or less distinctly keeled .. .. *C. rhombeatus.*
Snout prominent, more or less distinctly turned up at the end; scales smooth or faintly keeled .... *C. resimus.*

1. CAUSUS RHOMBEATUS.

Sepedon rhombeatus Licht. Verz. Doubl. Mus. Berl. p. 106.
Causus rhombeatus Bouleng. t. c. p. 467.

Tropical and South Africa.

2. CAUSUS RESIMUS.

Heterophis resimus Peters, Mon. Berl. Ac. 1862, p. 277, pl. – , fig. 4.
Causus resimus Bouleng. t. c. p. 468.

Eastern Soudan, East and Central Africa, Angola.

2. BITIS.

Gray, Zool. Miscell. p. 69; Bouleng. Cat. Sn. iii. p. 492.

1. BITIS ARIETANS.

Vipera arietans Merr. Tent. p. 152.
Bitis arietans Bouleng. t. c. p. 493.

Tropical and South Africa; Southern Arabia.

3. CERASTES.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. iii. p. 501.

1. CERASTES CORNUTUS.

Coluber cornutus Linn. in Hasselq. Reise Palæst. p. 315.
Cerastes cornutus Bouleng. t. c. p. 502.

Soudan and borders of the Sahara; Arabia and Palestine.

4. ECHIS.

Merr. Tent. p. 149; Bouleng. Cat. Sn. iii. p. 504.

Two species:—

Scales on snout and vertex more or less strongly keeled; 2 (rarely 1 or 3) series of scales between eye and upper labials; ventrals 132-192 . . . . *E. carinatus.*
Scales on snout and vertex smooth or obtusely keeled; 3 or 4 series of scales between eye and upper labials; ventrals 174–205 . *E. coloratus.*

1. ECHIS CARINATUS.

Pseudoboa carinata Schneid. Hist. Amph. ii. p. 285.
Echis carinatus Bouleng. t. c. p. 505.

Desert and sandy districts of Africa north of the Equator; Southern Asia, from Transcaspia and Arabia to India.

2. ECHIS COLORATUS Günth. P. Z. S. 1878, p. 978; Bouleng. t. c. p. 507, pl. xxv. fig. 1.

Egypt, Socotra, Arabia, Palestine.

5. Atractaspis.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 510.

Synopsis of the Species.

I. Anal divided; subcaudals paired; 4th upper labial entering the eye; scales in 19 rows	*A. engdahlii.*
II. Anal entire; subcaudals all or mostly single.	
4th upper labial entering the eye; a single large anterior temporal; scales in 31 rows	*A. phillipsi.*
3rd and 4th upper labials entering the eye; temporals small; scales in 23 rows	*A. leucomelas.*
3rd and 4th upper labials entering the eye; temporals small; scales in 29 to 37 rows	*A. microlepidota.*

1. Atractaspis engdahlii Lönnb. & Anderss. Ark. f. Zool. viii. 1913, no. 20, p. 5.

Somaliland.

2. Atractaspis phillipsi Barbour, Proc. Biol. Soc. Washingt. 1913, p. 148.

Sennar.

3. Atractaspis leucomelas Bouleng. Ann. Mus. Genova (2) xv. 1895, p. 16, pl. iv. fig. 2, and Cat. Sn. iii. p. 517.

Somaliland.

4. Atractaspis microlepidota Günth. Ann. & Mag. N. H. (3) xviii. 1866, p. 29, pl. vii. fig. 3; Bouleng. t. c. p. 517.

Egyptian Soudan, East and Central Africa.

47. Descriptions of a new *Amphisbæna* and a new Snake discovered by Dr. H. G. F. Spurrell in Southern Colombia. By G. A. Boulenger, F.R.S., F.Z.S.*

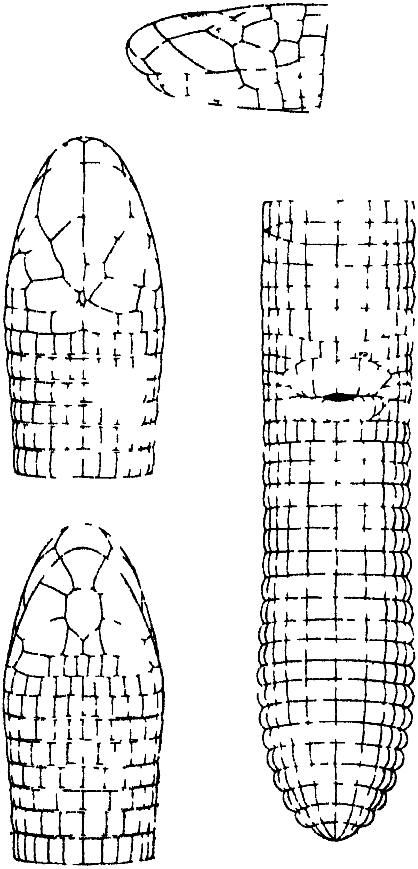
[Received October 29, 1915 Read November 23, 1915

(Text-figures 1 & 2.)

AMPHISBÆNA SPURRELLI, sp. n. (Text-fig. 1.)

Snout rounded, prominent. Rostral rather small, triangular, just visible from above; nasals forming a suture; a pair of

Text-figure 1.



Amphisbæna spurrelli. Upper, lower, and side views of head, and lower view of posterior part of body and tail.

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præfrontals, the largest head-shields, the suture between them once and a half to once and two-thirds as long as that between the nasals and slightly longer than that between the frontals, which are much smaller and a little longer than broad*; a pair of small occipitals; eye distinguishable under the ocular, which is situated between the præfrontal and the second and third upper labials and followed by two superposed postoculars; four upper labials, fourth small, second very large; symphysial trapezoid, the sides slightly concave, followed by a longer chin-shield; four lower labials, second largest. 213 or 214 annuli on the body, 21 to 23 on the tail; an annulus in the middle of the body contains 34 or 36 segments, 16 or 18 dorsal and 18 ventral, the dorsals at least twice as long as broad, the median ventrals once and a half to twice as broad as long; the dorsal segments on the distal half of the tail tubercular or subconical. Lateral line very distinct. 6 anal segments. 4 præanal pores. Whitish, each dorsal segment with an oval or squarish purplish-brown spot.

Length to vent 320 mm.; tail 28; diameter of body 10.

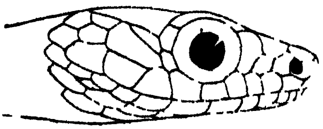
Two specimens from Anda Goya, at the junction of the R. Condoto and San Juan.

Distinguished from *A. darwini* D. & B. by the broader ventral segments and the tubercular segments on the tail.

HERPETODRYAS VICINUS, sp. n. (Text-fig. 2.)

Eye large, as long as the snout. Rostral once and one-third as broad as deep, just visible from above; internasals a little broader than long, a little shorter than the præfrontals; frontal once and a half as long as broad, longer than its distance from the end of the snout, slightly shorter than the parietals; loreal as long as deep; one præ- and two postoculars; temporals 2+2; nine upper labials, fourth, fifth, and sixth entering the eye; five lower labials in contact with the anterior chin-shields, which are shorter than the posterior. Scales in 10 rows, all smooth or the vertebral pair very faintly keeled; scales gradually decreasing in size towards the ventrals, the largest not half the size of the parietal shields. Ventrals not angulate laterally, 163; anal

Text-figure 2.



Herpetodryas vicinus. Side view of head.

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* In the specimen figured the left frontal has fused with the left occipital.

divided; subcaudals 149. Reddish brown above, anterior two-thirds of body with darker lines on the borders of the scales, forming faint cross-bands terminating in a spot on the outer series of scales; a series of irregular yellow spots or streaks along the vertebral line; posterior part of body and tail uniform brown with darker edges to the scales; a round blackish spot on each parietal shield; a short black streak behind the eye above the lip which is white, some of the shields finely black-edged; belly white in front, brownish behind; a dark streak along the tail at the junction of the subcaudal shields.

Total length 490 mm.; tail 190.

A single young specimen, also from Anda Goya.

Closely allied to *H. fuscus* L. Distinguished by the number of temporals (2+2 instead of 1+1), the greater extent to which the fourth upper labial borders the eye, the divided anal, and the more numerous subcaudals.

48. The Distribution of Secondary Sexual Characters amongst Birds, with relation to their Liability to the Attack of Enemies. By J. C. MOTTRAM, M.B. (Lond.)*.

[Received June 25, 1915: Read November 9, 1915.]

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This paper endeavours to show that there is a correlation between extra-sexual dimorphism among birds and their vulnerability to enemies. No attempt is made to account for this correlation. However, in the light of this correlation, the more important theories which have been put forward to account for the presence of secondary sexual characters are briefly considered.

Collection of Material.

In collecting material for classification, works were selected in which many facts were collected on broad lines and with no particular object in view. References are given for all the material used. The work from which by far the most material was taken is 'The World's Birds,' by F. Finn. This is a small volume, in which the families are briefly described in a systematic manner under the headings—diagnosis, size, form, plumage, young, nest, eggs, incubation, courtship, food, gait, flight, notes, disposition and habits, economic qualities, captivity and distribution. A wealth of reliable information is here laid down in a condensed manner, and is, therefore, at once available for classification.

Apart from this work, descriptive monographs have been chiefly consulted. Only families containing more than ten species are considered, as it was thought that a lesser number could not give a reliable picture of the characters of a family.

In order to escape any misunderstanding, the factors to be correlated must first be clearly defined. A species is said to show extra-sexual dimorphism when there is a difference between the somatic characters of male and female. Attention is usually directed to differences in form and colour, but it must be remembered that almost any character may show a difference. It is by no means uncommon to find birds in which the form and colouring of the sexes are identical, but it is quite rare to observe birds the males and females of which are entirely alike in every respect apart from their sexual and reproductive organs. Many, in describing the Song-Thrush, remark "sexes alike," forgetting the male's song; nevertheless, it is necessary in a consideration of this kind to accept the classifications of others.

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* Communicated by the SECRETARY.

Vulnerability to enemies is essentially a relative term. Unfortunately a classification of birds according to their vulnerability to enemies has not been found. It follows that this subject must be considered in detail.

Birds are subject to attack from the air by hawks, whilst feeding in trees from carnivorous mammals and reptiles, and when on the ground from all three. It follows that birds entirely aerial are more free from enemies than are arboreal or terrestrial ones, and birds entirely arboreal more free than terrestrial. All birds, with very few exceptions, are to some extent aerial. Sea-birds must be almost as free from enemies as aerial birds, as there is little evidence that they are preyed upon by any aquatic animals; and of sea-birds, the oceanic ones must be especially free from enemies, as hawks are not found far from land. The following table, compiled from Finn's 'World's Birds' (see Table I.), sets out the families from this point of view, and shows that birds relatively free from enemies present little sexual difference, whereas those presenting great sexual differences are only to be found amongst terrestrial and arboreal birds.

TABLE I.

	Terrestrial.	*Arboreal.*	*Aerial.*	*Aquatic.*	*Oceanic and Maritime.*
1. No sex difference ...	38% 8 [35%]	25% 4 [17%]	50% 4 [17%]	100% 2 [9%]	83% 5 [22%]
2. Usually no sex difference	24% 5 [33%]	31% 5 [33%]	50% 4 [27%]	—	16% 1 [7%]
3. Sometimes sex difference	9% 2 [40%]	19% 3 [60%]	—	—	—
4. Usually sex difference ...	29% 6 [60%]	25% 4 [40%]	—	—	—

NOTES.—Compiled from F. Finn's 'The World's Birds.'

2 = Usually no sex difference, and includes the following descriptions:—"Hardly ever a sex difference," "seldom a sex difference," "very slight or no sex difference," "small sex difference," "little s.d.," "rare s.d.," "oftenest alike," "usually small s.d."

4 = Usually sex difference, and includes the following descriptions:—"Sexes different," "often sex difference."

The above method of classifying secondary sex characters is used throughout the paper.

(*Continued at foot of next page.*)

The subject may be approached from other points of view. Many birds are more or less free from enemies on account of possessing powerful weapons of defence — either beaks, talons, wings (*e. g.*, swans), or legs (*e. g.*, cassowaries). Sexual dimorphism should be less commonly found among these birds than among birds in general; and such is the case, as shown in Table II., only hornbills and toucans being to some extent exceptional. On referring to Table III., it can be seen that these two families have been correctly described as exhibiting "sometimes sex difference," especially in the case of hornbills. As regards toucans, it can be seen that it is chiefly among the smaller and therefore less powerful species that sex dimorphism is found. This, however, is not the case in the hornbills. Although their bills are apparently very powerful, it is doubtful whether they are so in practice; keepers are of opinion that

TABLE II.

	No defensive weapons.		With defensive weapons.		
1. No sex difference	38%	11	52%	11	
2. Usually no sex difference	24%	7	38%	8	
3. Sometimes sex difference	10%	3	10%	2	Toucans & Hornbills.
4. Usually sex difference .	28%	8	—	0	

NOTES.— Compiled from F. Finn's 'The World's Birds.'

Secondary sex characters classified as before.

Reference Nos. —1 no def. 4, 8, 22, 25, 28, 29, 30, 32, 40, 45, 46 2 no def. 10, 26, 31, 37, 39, 42, 44 . 3 no def 11, 21, 38 : 4 no def. 5, 14, 16, 19, 21, 31, 41, 19 : 1 def. 1, 2, 6, 9, 13, 17, 18, 35, 36, 43, 48 : 2 def. 3, 7, 12, 15, 20, 27, 38, 50 . 3 def. 23, 47.

Notes to Table I., *continued.*

In a few cases birds have been placed in two columns, *e. g.* Pigeons in Terrestrial and Arboreal, Passerine Birds ditto, Divers in Aquatic and Maritime

Ducks have been placed under Terrestrial, as they are especially liable to the attacks of carnivorous mammals whilst feeding on dry land or in shallow water; they are considered in detail elsewhere.

The bracketed percentages refer to the horizontal lines, the unenclosed percentages to the vertical columns.

Reference numbers for Table I. :—

1 Terr. 6, 8, 9, 25, 29, 43, 45, 46 : 2 Terr. 20, 37, 39, 42, 33 : 3 Terr. 11, 23 : 4 Terr. 34, 5, 14, 16, 19, 41 : 1 Arb. 4, 28, 30, 48 : 2 Arb. 3, 26, 33, 37, 50 : 3 Arb. 23, 38, 47 : 4 Arb. 24, 10, 34, 16 : 1 Aer. 1, 4, 12, 32 : 2 Aer. 15, 31, 40, 44 : 1 Aq. 13, 17 : 1 Ocea. 2, 13, 18, 35, 36 : 2 Ocea. 7 : Nos. 10, 21, 22, 27 omitted.

These numbers refer to the list of birds at the end of the paper, and show how they are distributed in the table; they enable others to criticise the distribution.

a severe bite can only be given when the finger is seized far back in the bill: at the tip the leverage against the jaw-muscles must be very great, and, unlike most long bills, they are unsuitable for stabbing.

TABLE III.

	a.	v.sl.d.	sl.d.	so.d.	d.	
No. of species	18	7	3	3	11	Hornbills
Average wing-length	12·5	15·4	10·8	11·5	15·1	
No. of species	24	6	2	1	6	Toucans
Average total length .	18·3	17	14·5	13·5	13	

NOTES.—Compiled from Monographs on the Bucerotidæ by D. G. Elliot and the Ramphastidæ by J. Gould.
a.=sexes alike, v.sl.d.=sexes very slightly different, sl.d.=slightly different, so.d.=some difference, d.=different, v.d. (used in other tables)=very different.

If, instead of considering birds from the point of view of defence we classify them according to their offensive powers, the same conclusion results. Offensive powers are divided according as to whether the birds' diet consists of vertebrates, small vertebrates, invertebrates, or vegetable matter, as set out in Table III. *a*.

TABLE III. *a*. (Food of Birds.)

	Food consisting of		
	* Vertebrates.	Small Vertebrates and Invertebrates.	Small Vertebrates, Invertebrates, and Vegetables.
1	8	7	8
2	4	3	7
3	—	2	3
4	-	-	8

NOTES.—Compiled from F. Finn's 'The World's Birds.'
Numbers at column headings refer to secondary sex characters as before.
*Reference Nos.:—1 vert. 1, 2, 13, 18, 32, 35, 36, 43: 2 vert. 7, 12, 20, 27: 1 vert. & invert. 4, 8, 22, 25, 40, 44, 45: 2 vert. & invert. 15, 26, 31: 3 vert. & invert. 21, 28: 1 vert. & veg. 6, 9, 17, 28, 29, 30, 46, 48: 2 vert. & veg. 3, 10, 33, 37, 39, 42, 50: 3 vert. & veg. 11, 23, 47: 4 vert. & veg. 5, 14, 16, 19, 24, 34, 41, 49.

Further, certain birds for other reasons are especially free from enemies. Diving-birds have always a safe refuge at hand,

and should, therefore, present little secondary sexual differentiation. This is shown to be the case in Table IV. In this table ducks form an exception— for, though capable of diving, they often present sex dimorphism. In a previous table they were placed with difficulty, so that it is necessary to study them in more detail (see Table V.). This table shows that the diving-habit is associated with a reduction in the amount of secondary sexual difference. No doubt, had a larger amount of material been examined, exceptions would have been encountered; for instance, in the Spot-bill (*Anas pœcilorhyncha*) the sexes are

TABLE IV.

	Diving Birds.		Non-diving Birds.	
1	4	66%	18	42%
2	1	17%	14	32%
3	0	—	5	12%
4	1 (Ducks)	17%	7	14%

NOTES.—Compiled from F. Finn's 'The World's Birds.'

Sexual classification as before.

Reference Nos.—1 Div. 3, 13, 17, 35: 2 Div. 7: 4 Div. 11: 1 Non-div. 1, 4, 6, 8, 9, 18, 22, 25, 28, 29, 30, 32, 36, 40, 43, 45, 46, 48 · 2 Non-div. 3, 10, 12, 15, 20, 26, 27, 31, 33, 37, 39, 42, 44, 50: 3 Non-div. 11, 21, 23, 38, 47: 4 Non-div. 5, 16, 19, 24, 34, 41, 49.

TABLE V.

Diving Ducks.					Non-diving Ducks.				
a.	v.sl.d.	sl.d.	d.	v.d.	a.	v.sl.d.	sl.d.	d.	v.d.
-	2	3	3	7	—	—	—	—	10

NOTES.—Compiled from J. Gould's 'Birds of Europe,' vol. v.

Swans, Geese, and Sheldrakes, presenting little or no sex difference, were omitted.

The following list shows the placing of the ducks in the above table:—

Div. v.sl.d. *Fuligula leucophthalmos*, *Undina leucocephala*: Div. sl.d. *F. cristata*, *Oidemia fusca*, *O. nigra* · Div. d. *F. ferina*, *F. rufina*, *Mergus albellus*: Div. v.d. *F. marila*, *Clangula vulgaris*, *C. histrionica*, *Harelda glacialis*, *M. merganser*, *M. serrator*, *M. cucullatus*: Non-div. v.d. *Mareca penelope*, *Spatula clypeata*, *Anas boschas*, *Querquedula crecca*, *Q. glocitans*, *Q. circia*, *Dafila caudacuta*, *Chaulelasmus strepera*, *Somateria mollissima*, *S. spectabilis*.

alike, and perhaps the duck might be considered to be a non-diver, but E. C. Stuart Baker in 'Indian Ducks' says "it is a most expert diver."

The Marbled Duck (*Marmaronetta angustirostris*) forms a like exception, but has unusual habits, which to a large extent protect it from enemies. It never goes ashore; it remains nearly always in rushes. The Andaman Teal (*Nettion albigulare*) is another, but this bird is an insular species and is said to be entirely nocturnal.

However, examples more difficult to account for are to be found; for instance, the Whistling Ducks (*Dendrocygna*). These birds have arboreal habits, and at a sign of danger take to the trees. On the whole, therefore, although at first sight apparently serious exceptions, on more detailed examination ducks are found to fall into line with the rule that diving-birds exhibit less secondary sexual differences than non divers.

Very few, if any, birds can entirely escape from hawks by means of rapid flight (arboreal birds are to some extent free from their attacks). Two of the favourite quarries of the Eastern hawkers are teal and sand-grouse, among the most rapid fliers. There are, however, a few birds which are able by means of skilful dodging to evade the attacks of hawks for instance, the hoopoe, of which Finn says "it is easily able to escape from hawks."

TABLE VI.

	Birds mentioned as forming food for man.		No note re edibility.	
1	44 %	12	13 %	10
2	22 %	6	30 %	9
3	11 %	3	9 %	2 (Puff-birds and Honey-Guides).
4	22 %	6	9 %	2 (Trogons and Humming-birds).

NOTES.—Compiled from F. Finn's 'The World's Birds.'

Honey-Guides are not eaten by natives because they are useful in guiding them to honey; Humming-birds possibly because of their small size. Puff-birds are doubtfully described as presenting "sometimes sexual differences," as shown in the following table compiled from P. L. Sclater's 'Bucconidæ':—

	?	n.	s.l.d.
Puff-birds	33	8	2

?=no note made as to whether sexes are different or not.

As regards Trogons, other works have been consulted but with no result.

Reference Nos.:—1 edib. 2, 9, 22, 25, 29, 30, 32, 35, 36, 43, 45, 46: 2 edib. 7, 20, 33, 37, 39, 42: 3 edib. 11, 23, 47: 4 edib. 5, 14, 16, 19, 34, 41: 1 non-edib. 1, 4, 6, 8, 13, 17, 18, 28, 40, 48; 2 non-edib. 3, 10, 12, 15, 26, 27, 31, 44, 50: 3 non-edib. 21, 28: 4 non-edib. 24, 49.

Birds may avoid enemies in other ways; there is little doubt but that ill-flavour plays a part. Under the heading "Economic Qualities," Finn, in the 'World's Birds,' mentions those birds which form food for man, and this to some extent will separate the well-flavoured from the ill-flavoured. This material is set out in Table VI., which shows that secondary sexual dimorphism is especially to be found among table-birds.

Birds may also be said to avoid enemies by protective coloration. However, it is not possible to examine this aspect statistically, because protective coloration often forms a part of sex dimorphism, the female presenting this coloration and the male not doing so. This is in itself, however, evidence that sex dimorphism is in some way related to enemies.

Size.—Upon size must depend to some extent a species' vulnerability to enemies. Large birds are only open to the attack of large carnivorous animals, whereas small birds are preyed upon by both small and large. Large birds should, therefore, show less secondary sexual dimorphism than medium-sized birds, and these less than birds of small size. Finn describes the size of birds by comparing them with well-known English ones—for instance, of parrots he says "less than tit to that of an ordinary fowl," of hornbills "from that of a hen turkey to that of a pigeon." Birds thus used in description may be classified into large, medium, and small, and, with this as a measure, Table VII. has been compiled. Parrots would fall, therefore, into all three columns, and hornbills into medium and large.

TABLE VII.

	Large.		Medium-sized.		Small.	
1	55%	11	43%	18	33%	11
2 ..	20%	4	31%	13	12%	14
3	10%	2	10%	4	9%	3
4	15%	3	17%	7	15%	5

NOTES.—Compiled from F. Finn's 'The World's Birds.'

Table of measure for classification:—Large=swan, goose, turkey, "upwards," heron, 3 ft. and above in length: Medium=jay, dove, raven, rook, mallard, partridge, crow, fowl, pheasant, "medium size," pigeon, jackdaw, hen, duck: Small=lark, "very small," thrush, sparrow, blackbird, tit, swallow, quail, starling, linnet, "3 inches."

Reference Nos.:—1 L. 1, 2, 6, 9, 13, 18, 25, 32, 35, 36, 43: 2 L. 7, 12, 20, 37: 3 L. 11, 23: 4 L. 5, 14, 16: 1 M. 1, 2, 4, 8, 13, 17, 18, 22, 25, 28, 29, 32, 35, 36, 40, 45, 46, 48: 2 M. 3, 7, 10, 12, 15, 20, 27, 31, 33, 37, 39, 42, 50: 3 M. 11, 23, 38, 47: 4 M. 5, 14, 16, 19, 34, 41, 49: 1 S. 2, 4, 8, 17, 18, 22, 28, 30, 32, 36, 46: 2 S. 3, 10, 12, 15, 20, 26, 27, 31, 33, 37, 39, 42, 44, 50: 3 S. 21, 38, 47: 4 S. 16, 19, 24, 34, 49.

Secondary sex characters classified as previously.

The table shows that 15 per cent. of large birds, 17 per cent. of medium, and 15 per cent. of small often present sex differences. In this respect there is little difference, but of large birds 55 per cent., of medium-sized 43 per cent., of small 33 per cent. present no sex difference. Examination horizontally also shows that large birds less often present secondary sexual dimorphism than the medium-sized or small birds.

Instead of studying birds as a whole, certain families, chosen at random, have been examined by themselves with respect to the question of size. In barbets, jacamars, puff-birds, woodpeckers, and toucans the Tables III. and VIII. show that the smaller species present the most secondary sexual dimorphism. In hornbills and kingfishers, however, this association is not found, though the reverse does not hold.

Other families show the effect of size without any detailed analysis; for instance, in the Anatidæ swans and geese present little or no sex difference, and in the Falconidæ it is only the smaller species which show any sex difference.

On the whole, therefore, the consideration of size appears to support the thesis.

TABLE VIII.

		a.	v.sl.d.	sl.d.	so d.	d.	v.d.
Barbets	No. of species	20	—	1		1	3
	Average total length	8·0	—	7·4		6·0	5·8
	No. of species	43	1	1	1	3	4
	Average wing-length	3·44	3·1	3·4	3·3	3·23	2·60
Jacamars	No. of species	1	8	5	1	—	—
	Average total length	11	8·2	7·7	8	—	—
Puff-birds	No. of species	8	—	2	—	—	—
	Average total length	7·5	—	7·0	—	—	—
Kingfishers	No. of species	13	2	7	11	1	1
	Average length	9·5	10·2	12·0	10·0	8·5	9·0
Woodpeckers	No. of species	1	103	100	7	3	—
	Average length	24	27	22·6	19·7	21	—

NOTES.—Compiled from Monographs on the Capitonidæ by C. T. & G. L. Marshall; Galbulidæ and Bucconidæ by P. L. Sclater; Alcedinidæ by R. B. Sharpe; Picidæ by Alf. Malherbe.

For column headings, see Table III.

Sociability.—This is another factor which should protect birds from enemies to some extent. Numbers may be able to resist an enemy to which one would fall a victim. Sociable birds should, therefore, show less secondary sexual dimorphism—as is the case, see Table IX.

TABLE IX.

	Sociable Birds.	Not Sociable.
1	12	4
2	4	9
3	1	1
4	0	5

NOTES.– Compiled from F. Finn's 'The World's Birds.'

Of the remaining birds no note is made except Passerine birds, which are described as sometimes sociable.

Some birds form coveys or family associations out of the breeding-season—game-birds, for instance, and other birds form flocks, *e. g.* ducks.

Reference Nos :—1 Soc. 1, 2, 4, 9, 18, 22, 25, 30, 35, 36, 43, 48 · 2 Soc. 7, 33, 42, 44: 3 Soc. 47 · 1 Non-soc. 8, 28, 32, 45 . 2 Non-soc. 3, 10, 12, 20, 26, 27, 31, 39, 50 : 3 Non-soc. 21 : 4 Non-soc. 5, 16, 19, 24, 49.

Secondary sex characters classified as before.

Birds may also avoid enemies by having a habitat where they are free from enemies for instance, mountain-tops, islands, arctic regions, oceans. Oceanic species are included in Table I. The only other material with which it has been found possible to examine this question is Seebohm's monograph of the Turdidæ; for in this family there is a sufficient number of insular and continental forms for comparative purposes. Table X. sets out the material, and it can be seen that secondary sexual dimorphism is much less common in insular than in continental species. Of the four continental species of the genus *Merula* which present little secondary sexual dimorphism, it is noteworthy that there are three living high up on volcanic mountains.

TABLE X.

	Insular.						*Continental.*					
	a.	v.sld.	sl.d.	so.d.	d.	vd.	a.	v.sl.d.	sl.d.	so.d.	d.	v.d
Merula .	6	9	3	1	0	4	0	2 2 volcanic species.	2 1 volcanic species.	4	17	15
Geocichla	14	0	2	0	0	0	18	0	2	0	1	3
Turdus ...	8	-	--	--	—	-	36	—	6	—	2	--
Mimocichla	3	—	--			—		—	—	—	-	---

NOTE.—Compiled from H. Seebohm's 'Turdidæ.'

Endeavours were made to find other material in order to substantiate or not this remarkable correlation, but none was found suitable for classification.

Song, another secondary sexual character, was also treated in the same way, and clearly substantiates the former finding, as is shown in Table XI.

TABLE XI.

	Insular.			*Continental.*		
	Sing.	?	No song.	Sing.	?	No song.
Merula	5	18	3	17	21	1
Geocichla . . .	2	13	1	9	14	1
Turdus . .	1	7	1	30	16	1

NOTE.—Compiled from H. Seebohm's 'Turdidæ.'
? = No note was made with reference to song. No song includes such descriptions as "song not known," "bird is silent," "never heard."

Birds may be looked at with advantage from another point of view. In Table XII. they are classified according to their sexual dimorphism without reference to any other factor. Examination of this table (XII.) shows that among birds presenting no sexual difference (column 1) 10/22nds 45 per cent. are relatively free from enemies; among birds usually presenting no sex difference (column 2) 5/15ths 33 per cent.; among birds sometimes presenting sex difference 2/5ths 40 per cent., and among birds usually presenting sex difference 0/8ths 0 per cent. are free from enemies.

TABLE XII.

1.		2.		3.		4.	
N.L.	L.	N.L.	L.	N.L.	L.	N.L.	L.
10	12	5	10	2	3	0	8
45 %		33 %		40 %		0 %	

NOTES.—Compiled from F. Finn's 'The World's Birds.'
Numbers at column headings refer to secondary sex characters as before. N.L. = not liable to attack; L. liable to attack; % = percentages of birds not especially liable to the attack of enemies. This is a synopsis of the previous table.
Reference Nos. :—1 N.L. 1, 2, 6, 13, 17, 18, 32, 35, 36, 43 : 1 L. 4, 8, 9, 22, 25, 28, 29, 30, 40, 45, 46, 48 : 2 N.L. 7, 12, 20, 33, 44 : 2 L. 3, 10, 15, 26, 27, 31, 37, 39, 42, 50 : 3 N.L. 23, 47 : 3 L. 11, 21, 38 : 4 L. 5, 14, 16, 19, 24, 34, 41, 49.

Thus it is clear that birds liable to attack more commonly present secondary sexual differences than birds not so liable to attack. If, instead of considering birds from a broad standpoint, a more detailed analysis be made, the same result is arrived at. In the case of passerine birds, powerful species are only to be found amongst those showing no sex dimorphism, *e. g.*, crows, drongoes, shrikes. Swallows, which are aerial birds, present little or no sex dimorphism.

The classification of sexual dimorphism chosen for analysis refers almost entirely to sexual dimorphism of colour; nevertheless, it will be advantageous to consider briefly other secondary sexual differences-- song and precopulatory displays.

As regards song, this character is frequently to be found in birds presenting no sex differences in colour and form, but which, nevertheless, do not appear to be especially free from the attack of enemies - for instance, among warblers, American warblers, wrens, cuckoos, larks, pigeons; whilst among birds not liable to attack, song-birds are very uncommon, if not entirely absent.

It thus appears that this dimorphic character is correlated to vulnerability to enemies, and accounts for some of those cases of birds presenting little or no sexual dimorphism of form or colour, but which are yet liable to the attack of enemies.

Precopulatory displays, or the displays of courtship, is another secondary sexual character open to investigation. Here, again, birds showing little or no display are birds not liable to attack, whereas birds showing great display are especially liable to attack. In the 'World's Birds,' under the heading "Courtship," sexual displays are briefly described in 25 of the 50 families under consideration. In the case of 19 of the 25 the usual actions are described: against diurnal birds of prey there is the remark "never seen the display," divers "said to be on the wing," hornbills "little known"; whilst against bustards "very elaborate," game-birds "elaborate," cranes "very elaborate." Cranes, then, form an exception, for they possess weapons of defence. Nevertheless, certain factors might lead one to suspect that they are not entirely free from attack; they are terrestrial birds, they are excellent-eating (their food being mostly vegetables, seeds, etc.), and in the East they are a favourite quarry of the hawker; they are also usually not sociable during the breeding-season, and, lastly, in most species both sexes take equal part in the displays, so that in truth they do not present secondary sexual dimorphism in this respect.

It is very fortunate that cranes needed this detailed consideration at the end of the examination, which has covered a great deal of material, as it is easy to draw attention to the fact that this is almost the only occasion (ducks also) when such treatment became necessary.

Summing up, it may be said that for certain reasons—namely, because of aerial, aquatic, and oceanic habits, possession of defensive and offensive weapons, of diving-habits, of ill-flavour to man, of large size, of insular habitat, of social disposition, of carnivorous habits—certain birds must be relatively free from the attacks of enemies; and it has been shown that these birds present less secondary sexual dimorphism than birds which for other reasons—namely, possession of terrestrial and arboreal habits, of no defensive weapons, of non-diving habits, of no ill-flavour to man, of small size, of continental habitat, of solitary disposition, and of non-carnivorous habits—have been considered to be relatively liable to the attack of enemies. These two factors thus appear to be correlated, but it is obvious that, though great sexual dimorphism is only to be found amongst birds liable to attack, nevertheless the converse does not hold, for some birds which do not appear to possess any special characters which would protect them from attack, none the less fail to present any secondary sexual dimorphism, *e.g.* ibises, mound-birds, mouse-birds, rollers, barbets, and coursers.

Conclusions may be briefly stated :—

(1) Among birds specially liable to the attack of enemies, secondary sexual dimorphism is chiefly to be observed.
(2) Among birds not specially liable to attack of enemies, secondary sexual dimorphism is rarely found.
(3) In both cases, birds presenting no sexual differences are represented, but much more commonly in birds more or less free from attack of enemies.

Having come to these conclusions, it will not be out of place to examine briefly the more important theories put forward to account for secondary sexual dimorphism, in order to discover whether any of them be substantiated or not.

Exuberance of Vital Energy in Males.—Wallace, in 'Tropical Nature,' believed that natural selection could account for secondary sexual dimorphism, by supposing that only the strongest and most virile males gained mates, and that these mates thus came to possess an excess of vital energy which became manifest in bright plumes, etc. If this be so, it is difficult to see the reason why birds vulnerable to enemies should be specially picked out. One would think that it would be dangerous for these birds to make themselves thus conspicuous, and would have anticipated that birds not liable to attack could have done so with more impunity.

Sexual Selection (Darwin, 'Descent of Man').—The argument used above applies similarly against Darwin's theory, which in no way can account for the correlation under examination. One would have thought that female selection would have had freer play among birds more or less free from enemies than among birds frequently subject to their attack.

Nesting-Habits Theory (Wallace and others).— It has been noted that birds liable to the attack of enemies, and making open nests, more frequently present secondary sexual dimorphism than birds making closed nests. If, however, birds liable to the attack of enemies more often present secondary sexual dimorphism than birds in general, then it follows that birds making open nests, and also liable to the attack of enemies, must do likewise.

It is thus obviously necessary to decide which is the more important correlating factor—vulnerability to enemies or open-nesting habits. Table XIII. deals with birds making open nests and in no way helps to decide the point; coursers, ibises, mouse-birds, tinamous, touracous, pigeons, rails, shore-birds, according to the "nesting-habit hypothesis," should present sex dimorphism, but they also fail to fall into line with the other correlation.

TABLE XIII. (Open-nesting birds.)

	Not especially liable to attack.		Liable to attack.	
1.	American Vultures, Cassowaries, Cranes, Divers, Grebes, Gulls, Storks, Penguins.	8	Coursers, Ibises, Mouse-birds, Tinamous, Touracous.	5
2.	Cormorants, Birds of Prey, Herons, Nightjars?	4	Pigeons, Rails, Shore-birds.	3
3.	——		Curassows.	1
4.	——		Bustards, Game-birds, Humming-birds, Sand-Grouse.	4

If, however, one turns to closed-nesting birds (Table XIV.), it is at once obvious that open-nesting habit plays no part, because several of the groups present considerable secondary sexual dimorphism, and quite a large number a small amount.

TABLE XIV. (Closed nesting birds.)

1.	Bee-Eaters, Hoopoes, Rollers, Motmots.	4
2.	Barbets, Jacamars, Kingfishers, Parrots, Woodpeckers.	5
3.	Hornbills, Toucans.	2
4.	Trogons.	1

NOTE. Compiled from F. Finn's 'The World's Birds.'

Table XV. continues the two previous tables, and also deals with families of birds making both open and closed nests. It shows that the relation between open-nesting habits and secondary sexual dimorphism is, if not entirely negligible, at any rate not nearly so close as with vulnerability to enemies. It may be mentioned that the Australian warblers (Maluridæ) present great sex difference (the males are amongst the most brilliant of birds), and yet they make closed nests. They are small defenceless birds, and so they not only form exceptions to the open-nesting theory, but support the correlation under consideration.

TABLE XV. (Nesting-habits.)

	Open nests.	Open and closed nests.	Closed nests.
1 ...	13 65% 52%	3 15% 33%	4 20% 33%
2...	7 47% 28%	3 20% 33%	5 33% 42%
3	1 33% 4%	——	2 66% 17%
4 . .	4 50% 16%	3 37% 33%	1 13% 8%

NOTES.—Compiled from F. Finn's 'The World's Birds.'

Honey-guides, parasitic; the rest, nesting-habits not mentioned.

Reference Nos. to middle column, the others are to be seen in Tables XIII. and XIV. 1 open and closed, 2, 32, 36: 2 open and closed, 10, 15, 44: 4 open and closed, 14, 19, 34. Percentages to right of figures = horizontal percentages, percentages below = vertical percentages.

Further, it is noteworthy that Honey-guides (Indicatoridæ) sometimes present sexual differences (Finn), and yet these birds are parasitic. This exception is important because it shows that the rearing of young as well as the open-nesting habits cannot account—in this case, at any rate—for secondary sexual dimorphism.

The Aphrodisiac Theory.—Those who believe in the necessity for an aphrodisiac (bright feathers, sexual display, and song) must assume coyness on the part of the female. Little, if any, attempt, however, is made to establish this important sexual difference—a coy female and an impudent male. There does not appear to be any reason why the females of birds especially subject to the attack of enemies should be especially coy, or that among birds not especially subject to attack the females should not require a powerful stimulant.

The Catabolism Theory (Prof. Geddes and Thomson, 'Evolution of Sex,' 1889).—The secondary sexual structures found in the males are considered to be due to a katabolic constitution, and their absence in the female due to an anabolic tendency.

No attempt is made to explain the distribution of secondary sexual characters among birds on this theory, or to give a reason why some birds present great extra-sexual difference and others little or none. The conclusions arrived at in this paper do not appear to be explicable on this theory; there seems to be no reason, for instance, why birds especially subject to the attack of enemies should be more katabolic than birds not especially so subject.

The Mendelian Theories.—Although the followers of Mendel have carried out very important investigations with regard to secondary sexual characters, as far as I am aware, they have made no attempt to account for the distribution of these characters in the animal kingdom.

The Hormone Theory ('Archiv für Entwicklungsmechanik,' 1908), J. T. Cunningham.—According to this theory, secondary sexual characters become established in the following manner:—As a result of certain mechanical and functional stimuli, confined, for instance, to the male, certain organs of the male take on new characters: these are acquired characters. During their production a specific hormone is produced, which stimulates the corresponding determinant in the gametes and alters them in such fashion that, during development, they reproduce the acquired character; but it also alters them in another direction—it implants in them an ability to reproduce the acquired character only in the presence of the male sexual hormone. In the absence of the male sexual hormone, the character cannot develop: for instance, if a stag be castrated the antlers cannot develop on account of the absence of the male hormone—the character remains dormant. Obviously the material here dealt with applies only to the first part of the theory, that dealing with mechanical and functional stimuli.

In the case of birds the functional stimuli, which call forth the bright plumes of the males, are those associated with the display of these ornaments during courtship. "the tail of the peacock became brilliant and hypertrophied because it had been constantly erected." The stimulus calling upon the male to display seems, therefore, to be the deciding factor. Thus in order to support this theory, it would be necessary to show that the males of birds subject to enemies suffer more from such stimuli than do those birds relatively not liable to be attacked.

Finally, it is necessary to point to the importance of the correlation under consideration with respect to the possibility of it being able to account for the presence of secondary sexual characters.

The activities of animals fall under three headings:—

(1) Those associated with the procuring of food.
(2) „ „ escape from enemies.
(3) „ „ reproduction.

It has usually been thought that the sexes bear the same relation to the environment as regards the procuring of food and the escape from enemies; and therefore to account for secondary sexual characters, search has always been made in the reproductive environment. But the correlation between secondary sexual dimorphism and vulnerability to enemies indicates that a solution to the problem may possibly be found to be related to the activities associated with the escape from enemies, and especially if it could be shown that the sexes do not bear the same relation to the environment as regards escape from enemies.

The author has attempted to show elsewhere ('Controlled Natural Selection,' 1914) the lines along which solution may possibly lie.

Reference List of Birds.

1. American Vultures (Cathartidæ).
2. Auks (Alcidæ).
3. Barbets (Capitonidæ).
4. Bee-eaters (Meropidæ).
5. Bustards (Otididæ).
6. Cassowaries (Casuariidæ).
7. Cormorants (Phalacrocoracidæ).
8. Coursers (Glareolidæ).
9. Cranes (Gruidæ).
10. Cuckoos (Cuculidæ).
11. Curassows (Cracidæ).
12. Birds of Prey (Falconidæ).
13. Divers (Colymbidæ).
14. Ducks (Anatidæ).
15. Frogmouths (Podargidæ).
16. Game-birds (Phasianidæ).
17. Grebes (Podicipedidæ).
18. Gulls (Laridæ).
19. Hemipodes (Turnicidæ).
20. Herons (Ardeidæ).
21. Honey-guides (Indicatoridæ).
22. Hoopoes (Upupidæ).
23. Hornbills (Bucerotidæ).
24. Humming-birds (Trochilidæ).
25. Ibises (Ibididæ).
26. Jacamars (Galbulidæ).
27. Kingfishers (Alcedinidæ).
28. Motmots (Momotidæ)
29. Mound-birds (Megapodiidæ).
30. Mouse-birds (Coliidæ).
31. Nightjars (Caprimulgidæ).
32. Owls (Strigidæ).
33. Parrots (Psittacidæ).
34. Passerine Birds (Passeridæ).
35. Penguins (Spheniscidæ).
36. Petrels (Procellariidæ).
37. Pigeons (Columbidæ).
38. Puff-birds (Bucconidæ).
39. Rails (Rallidæ).
40. Rollers (Coraciidæ).
41. Sand-Grouse (Petroclidæ).
42. Shore-birds (Charadriidæ).
43. Storks (Ciconiidæ).
44. Swifts (Cypselidæ).
45. Thick-knees (Œdicnemidæ).
46. Tinamous (Tinamidæ).
47. Toucans (Rhamphastidæ).
48. Touracous (Musophagidæ).
49. Trogons (Trogonidæ).
50. Woodpeckers (Picidæ).

49. Some Observations on Pattern-Blending with reference to Obliterative Shading and Concealment of Outline.

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(Text-figures 1–5.)

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This paper endeavours to show that the patterns found on animals may in many cases be of use in concealment after they have become blended with distance, and that the patterns of many animals are not intended to represent pictures of their backgrounds, but are aids to concealment only after blending.

Distance at which Blending takes Place.

If a surface of black and white squares or of black and white lines, or black and white spotted surfaces be examined from successively increasing distances, a point will be reached where the pattern can no longer be seen but is replaced by an even grey tone. The distance at which this change takes place was found to depend on the size of the black and white areas. The diagram (text-fig. 1) indicates the distances at which blending takes place in

Text-figure 1.

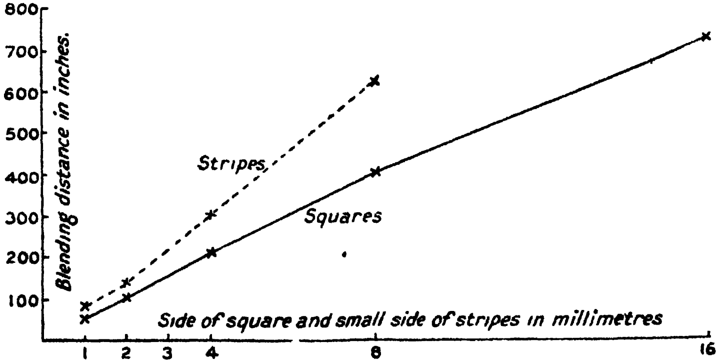

Diagram showing blending distances. Experimental conditions as in text-fig. 5, 1.

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* Communicated by the SECRETARY.

the case of alternate black and white squares and stripes under the experimental conditions stated.

Further experiments showed that the blending distance of different shapes depends upon the relative concentration of the black and white areas, the more concentrated the greater the blending distance. If, for instance, a checkered surface composed of squares of 2 square millimetres be compared with a surface composed of black and white oblongs of 1 multiplied by 4 mm. or ·5 multiplied by 8 mm. or ·025 by 16 mm., as regards the blending distance, it will be found that the distance is greatest for the squares and least for the narrowest oblongs. On comparing squares with other figures in this respect, for instance, with circles or triangles, it was found that the blending distance was related to the concentration of the various shapes.

The Surface which Results after Blending.

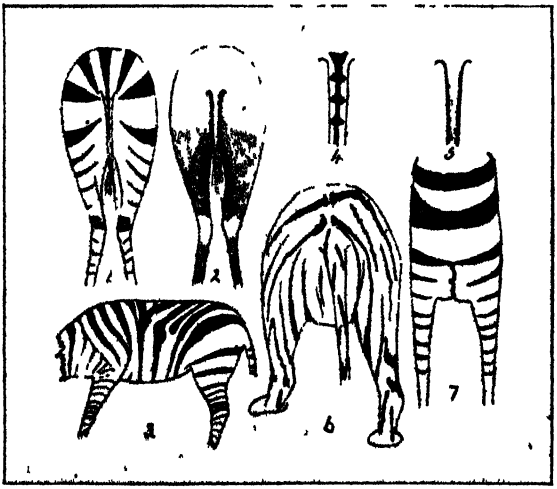
If a patterned surface of black and white be gradually approached from a distance, the surface which at first appeared of a perfectly even grey tone will, at a certain point, become granular, and a very short distance in front of this the pattern will suddenly shine forth clear and defined.

By varying the relative proportion of black to white in the pattern, all tones of grey can be produced when the pattern is blended. It is thus possible to match a given grey surface by means of black and white pattern, and also possible to reproduce a graded surface of grey: text-fig. 3, *1*, shows without any description how this can be done. If these copies of greys with patterns be fixed to solid figures such as a cylinder and be then examined, it will be found that after blending, the copies are undisturbed. It follows that the obliterative shading so commonly seen on animals and consisting of low tones where the light strikes, high tones in the shadows, and intermediate tones between the two, could be reproduced by means of pattern. Search has therefore been made amongst animals to discover whether this method exists.

Some Examples of Animals which appear to show Obliterative Shading by means of Pattern-Blending.

Grant's Zebra (*Equus burchelli granti*).—This animal's coat is coloured black and white, black stripes on a white background: the background, unlike that of the vast majority of animals, presents no obliterative shading, it has the same tone throughout; the stripes are somewhat darker on the back than they are below. On referring to text-fig. 2. *3*, it can be seen that on the dorsal surface of the animal and on those parts of the body where the light strikes, the stripes are broad, whereas on those parts which under natural conditions would be in shadow, the stripes are narrow: further, on those areas which would be more or less evenly lit, as for instance the vertical surfaces of the legs and sides of the face, the stripes maintain a more or less constant width. From what has been observed under experimental conditions as regards pattern-blending, it is obvious that, if one considers only the trunk of this animal, the varying widths of the stripes after blending must produce a condition of grey similar exactly to obliterative shading as seen, for instance, in the ass.

Text-figure 2.



1. Grant's Zebra (*Equus burchelli granti*) hind view.
2. The same view, stripes omitted, showing chief shadows under top lighting.
3. Lateral view of same animal.
4. Hind view of base of tail showing pattern.
5. Hind view of base of tail, pattern omitted showing shading as in 2.
6. Hind view of Tiger (*Felis tigris*) showing pattern.
7. Front view of Grant's Zebra, showing pattern.

Amongst big-game hunters there is a difference of opinion as to whether this animal is easily seen or not, under natural conditions. It appears that this difference of opinion is largely due to the district in which the hunter has observed these animals. In some districts the zebra is relatively tame and the hunter can frequently approach to within the blending distance of the pattern, which has been variously estimated, according to the lighting: under these conditions the zebra will of course appear a very conspicuous animal. On the other hand, in those districts where near approach cannot be gained on account of the open nature of the country or wildness of the animal, the hunter will look upon the zebra as one of the most difficult wild animals to pick up.

Of the zebras, *E. burchelli* presents between the stripes considerable obliterative shading, as well as faint stripes of buff. *E. grevyi* also has some obliterative shading, *E. zebra* very little, and *E. burchelli granti* none at all. Complete absence is, however, not uncommonly seen in all the species.

Thayer, in 'Concealing Coloration in the Animal Kingdom,' looks upon the striped coat of this animal as an obliterative picture-pattern of rank grasses and tree-stems: it is noteworthy that he makes no mention of the absence of obliterative shading, which he elsewhere insists always forms the canvas for picture-painting. If, however, examination be made of the pattern to be seen on viewing a zebra from behind (see text-fig. 2, *1.*), it is at once evident that this does not represent a picture-painting of reeds, herbage or trees. On the other hand, it illustrates in a remarkable way obliterative shading by means of pattern. Text-fig. 2, *2*, is a modelled drawing of the same view with the stripes omitted, the lighting being from above, and shows the major shadows which are cast. On comparing these two figures it can be seen that in the high lights, the stripes are broad, and that as one passes into the shadows, they fade away: where the high light strikes the hocks the bands are broad, whereas below the hocks where the leg is in the shadow, the stripes are narrow. The striping on the tail even falls into line, as shown in text-fig. 2, *4*, *5*.

The Guineafowl (*Numida meleagris*).—This bird illustrates obliterative shading by means of white spots on an even blue-grey background (text-fig. 3, *1*, bottom right-hand square). On the back the white spots are small, but become larger as one passes to the ventral aspect, where they are four times the diameter of those on the back. In some species the wings are covered with a series of short white bars, narrow on the back and broader below, as the wing lies covering the body during rest. These markings on the bird blend at a comparatively short distance; within the blending distance the bird appears conspicuous, beyond, difficult to see. The bird lives in open country, and there does not appear to be anything in its surroundings which this pattern emulates.

The Cheetah (*Cynælurus jubatus*).—The pattern, as shown in text-fig. 3, *1*, bottom left-hand square, consists of black spots on a pale fawn background: the background presents either no obliterative shading or very slight; the spots are close together on the back, gradually becoming more distant towards the ventral surface, which is hidden by a fringe of long hairs projecting downwards from the flank.

The Serval (*Felis serval*) presents a similar pattern to the Cheetah except that in the dorsal region, spots are replaced by short bars. This kind of pattern is commonly seen in the Civets.

The Jaguar (*Felis onca*).—Here the pattern is laid on a background presenting very little obliterative shading: on the back are closely placed black spots; as the ventral surface is approached the spots are seen to contain a central light brown area which gradually increases in size, whilst the surrounding dark ring diminishes and on the ventral surface becomes broken up into a number of separate spots irregularly arranged around the central area. This central area is always somewhat darker than the background and usually contains a small central black spot. Viewed as a whole this rather complicated pattern (see text-fig. 3, *17*) shows a decreasing quantity of black from above, downwards, and when blended at distance will produce a graded tone similar to obliterative shading. A similar pattern is found in the Ocelot (*F. pardalis*) and in several varieties of the Leopard, where it is often associated with an entire absence of obliterative shading.

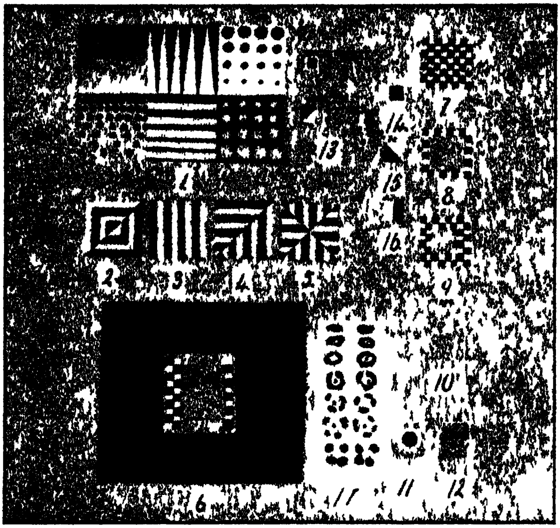
These patterns found in the genus *Felis* have been considered to be picture-paintings of a checkered background, for instance, leaf-shadows on bare ground; but the extreme regularity of these patterns is so unlike the very irregular nature of such backgrounds and so unlike the patterns which undoubtedly *do* simulate these backgrounds, that this deduction does not appear to be well founded: especially as these patterns blend at a comparatively short distance, probably within the charging length of the cat: and lastly, several of these animals inhabit open country.

However, apart from this consideration, the facts remain that these patterns will produce after blending obliterative shading, which is otherwise not presented; and these patterns must in this respect be powerful aids in concealment.

Sufficient examples have now been given to illustrate that this method of concealment is by no means uncommonly utilised. Black and white has been chiefly dealt with, but any colour can be produced by the blending of patterns consisting of two or more colours: examples of this are not difficult to find, for instance brown is often produced by the blending of buff and black.

Experiments were carried out to discover whether this method of coloration had any advantage over an unpatterned one. If a grey disc be examined in front of a series of backgrounds varying from black to white, a particular background will be found against which the grey disc is invisible, this being of course that background which is of an exactly similar tone to the disc: against the other backgrounds the disc will be visible at varying distances. If the results so obtained be compared with those obtained when a disc of black and white squares, which after blending produce the same tone of grey as the original disc, is substituted, it is found that the checkered disc possesses no advantage as regards the distances at which it can be seen, over the plain disc. There is, however, an exception: against the background on which the plain disc is invisible, the checkered disc is of course visible within blending distance, and against backgrounds closely similar to this background the checkered disc is at a disadvantage as regards invisibility. Over a long series of experiments there was some indication that against other backgrounds the checkered disc was slightly less visible, the measure being the greatest distance at which the discs could be seen; but although great care was taken with the constants of the experiment, the differences were too small and the experimental error too large, to justify a definite conclusion, particularly as the appearance of the checkered disc after blending was remarkably different from that of the plain disc. When the plain disc was visible, its outline was seen to be sharp, so that its shape could easily be recognised, but with the checkered disc the outline was remarkably indistinct, so that it was frequently impossible to tell whether a square, circle or equilateral triangle had been placed against the background. Experiments were carried out in order to determine the factors controlling this obscuring of form. Four squares were prepared as shown in text fig. 3, *2–5*: as can be seen, these squares consist of black and white areas of equal proportions. In fig. *3* the areas are interrupted along the two opposite margins, in fig. *4* along the two adjacent margins, in fig. *5* along all four edges, and in fig. *2* there is no interruption at the margins. These squares were examined under different conditions of lighting and against

Text-figure 3



Examples of obliterative shading by means of pattern-blending different toned backgrounds, and it was found that on all occasions marginal indistinctness after pattern-blending occurred where the black and white areas were interrupted at the edges; for instance, fig. *2* appeared as a grey square whilst fig. *5* showed an ill-defined grey area fading into the background. It was noted that when the background was near in tone to the squares after blending of the pattern, this obscuring effect was most marked: when the background was far removed in tone, for instance was black, or white, very little obscuring was noticeable. Other experiments showed that the greater the width of the black and white areas passing out at the margin, the greater the obscuring effect after pattern-blending.

One is now in a position to conclude that the method of obliterative shading by pattern-blending, as seen for instance in the Zebra, if it does not possess an advantage over the usual method as regards visibility, as measured by the distance at which the object is visible, nevertheless would seem to have a decided advantage in that the contour or silhouette of the animal against backgrounds approaching it in similarity, is made blurred rather than sharp. It is noteworthy that the stripes of the Zebra everywhere pass out at the margins (see text-fig. 2, *1*, *3*, and *7*).

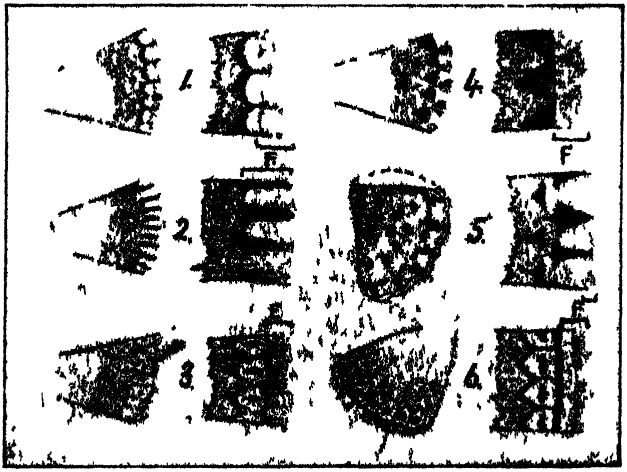
Referring to the possibility of the Zebra's stripes being pictures of reeds in high light and shadow, as has been suggested by Thayer, it is noteworthy that the black stripes decrease in breadth from above, down, which is contrary to expectation and to what actually is found among other animals. Thayer has pointed out that the markings on the backs of animals are usually smaller than those on the ventral aspect, because they represent objects in the landscape more distant: they depict the foreshortening of the ground. If reeds are painted on the zebra's back, one would at least have expected the stripes to be of equal width.

The Tiger presents an excellent example of reed-painting: on a coat showing well-marked obliterative shading, dark stripes are to be seen, they are irregularly distributed, they for the most part increase in width from above, down, and on the belly they terminate in a large dark mass which, curiously enough, often shows a small white centre (compare text-fig. 2, *1* with text-fig. 2, *6*).

Examples of outline-masking by means of pattern-blending at the margins are very commonly seen amongst Lepidoptera, but before considering instances, some experiments must be referred to. If one takes two flat surfaces, one an even dark grey and the other an even light grey, and brings them in apposition as shown in text-fig. 3, *6*, the junction will appear sharp, no matter how viewed. If now, at the junction a narrow band of black and white squares, which after blending will have the same tone as the light square, be interposed, see text-fig. 3, *6*, it will be found that the junction no longer remains sharp; if the outer square be replaced by areas of different tones varying from light grey to very dark grey, the same result will be seen. It is easy to see that, supposing the central square was an insect and that the different tones placed outside were the various backgrounds against which it would be likely to be seen, then the possession of a checkered margin would be a great aid towards its concealment.

To further test this property of an interrupted margin, squares were made as shown in text-fig. 3, *7–10*. these squares were made so that after pattern-blending they all appeared of the same tone. They were examined against a series of backgrounds and it was found that, whereas *10* remained for the most part sharp, the others showed blurred outlines; the blurring effect in the case of square *7* was not appreciably different from that of *8* and *9*. It appears therefore that a comparatively narrow broken margin is effective.

Text-figure 4.



Examples of marginal patterns. F=fringe of scales projecting from wing-margin.

1 Dingy Skipper, *Hesperia tages* ♀, dorsal surface of anterior wing.

2 Grizzled Skipper, *H. malvæ* ♀, dorsal surface of anterior wing pattern confined to fringe.

3 Common Blue, *Lycæna icarus* ♂, ventral surface of anterior wing pattern of marginal eye-spots.

4 Chalk-hill Blue, *L. corydon* ♀, dorsal surface of anterior wing pattern chiefly confined to fringe.

5 Painted Lady, *Pyrameis cardui*, dorsal surface of posterior wing.

6. Long-tailed Blue, *L. bætica*, ventral surface of posterior wing pattern at some distance from margin.

A few examples of this mode of concealment are given in text-fig. 4: it may be mentioned that outline-masking in insects is also brought about by scalloping of the margin and by a fringing of projecting scales; other methods are utilised, but these two are specially mentioned as they enter the chosen examples.

Examination of the wings of insects showed that this marginal pattern is often a short distance from the extreme edge; experiments were therefore carried out to discover at what distance the marginal pattern would be effective. A grey square (text-fig. 3, *6*) was examined against varying backgrounds with the checkered margins (equal in tone after blending) placed at varying distances opposite free margins, as shown in the figure. It was found that the marginal blurring, produced by the checkered patterns, was effective when they were placed a very short distance from the margin. Up to the width of the squares used some effect was noticeable, but was much more marked when the distance was produced to one half or a quarter of this. The single row of squares appeared to be almost as effective as the double; attempts were made to obtain more definite results, but in the absence of some method for estimating the amount of blurring, this was found to be impossible. Text-fig. 4, *6*, is an example in which the marginal pattern is separated a short distance from the free edge.

As eye-spots are frequently to be seen near the margins of the wings in Lepidoptera, it was thought that they might play some part in concealment of form by means of outline-blurring. A few experiments were carried out to discover whether this be so or not. In the centre of a small grey area, an eye-spot was placed consisting of a black centre surrounded by a white ring, the proportion of black to white being so arranged that, after blending, they were equal in tone to the surrounding grey: a similar grey area was prepared but with no central eye-spot: these two squares were then examined against various backgrounds; at the same time the squares were gradually reduced in size: it was then found that when the square (text-fig. 3, *11*) was reduced to 12·75 mm., the edges began to be blurred as compared with the edges of text fig. 3, *12*, especially against backgrounds not widely different in tone. Further reduction of the square to 10·3 mm. heightened the difference.

In this particular experiment the size of the eye-spot was: total diameter 6·75 mm., black centre diameter 4 mm. Eye-spots of different diameters were also used, and it was found that the larger the spot, the greater the distance at which marginal blurring was produced. Some experiments were also made, in which the eye spots were drawn so that after blending they were different in tone from the surrounding grey. It was found that they were not very effective in margin-obscuring unless the background was closely similar to their tone, after blending: they appeared as either light or dark areas on the grey square. An experiment was next devised to discover whether this outline-blending, by means of an eye-spot, was more effective than other patterns. As shown in text-fig. 3, *13*, a grey square was prepared, in one corner of which a square eye-spot was placed, in another corner a square of the same size and containing the same proportion of black and white but distributed on either side of the diagonal, in a third angle a similar square divided down the middle, the fourth angle was left unoccupied. This square was then examined against various backgrounds. Two facts were recorded: first, the eye-spot blended at a much shorter distance than the other two black and white squares, and secondly, the eye-spot square more effectively blurred the angle of the grey square than did the other two patterns. It was, however, difficult to decide how much difference there really was, because at the distance at which the eye-spot was blended and producing blending at the corner of the square, the other two patterns had not blended. In order to show the differences in the blending distance: under the conditions of the experiment, the blending distances of these patterns (text-fig. 3, *14–16*) were as follows: eye-spot 18½ feet, diagonally divided square 32½ feet, medially divided square 35 feet. Eye-spots distributed over a surface are often used for producing a pattern; in Lepidoptera they often form marginal patterns, but more frequently form patterns some distance from the edge, as is also the case in the Jaguar (see text-fig. 3, *17*).

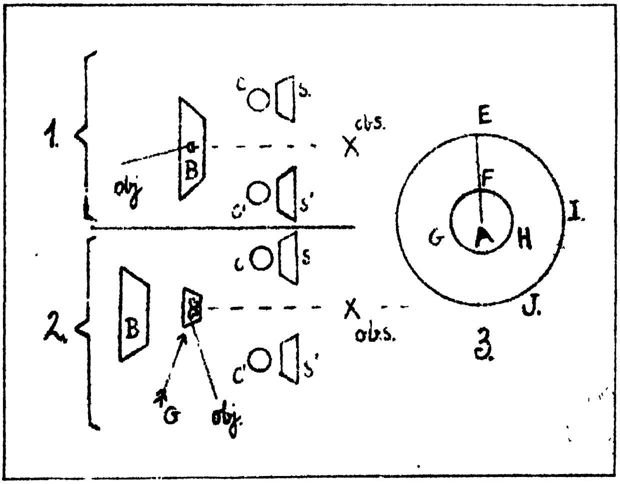
It appears that a given quantity of black and white, used as circular eye-spots, forms a pattern which obscures the outline, if not better, at any rate as well as other patterns. In order to be effective in this respect the eye-spot, after blending, should not make a contrast in tone with its ground; this was found to be the case as regards the eye-spots on the under wings of a number of butterflies examined: for instance, when the groundwork was light, the dark in the eye-spot was either small or not deep in tone.

Other possible uses for eye-spots have been put forward: they have been thought to be attraction marks which induce the attacking enemy to strike them rather than vulnerable parts; they have been looked upon as "dazzlers" to divert the enemy's eye from the insect as a whole. If one examines the larger eye-spots and those on the dorsal surface of the wings of many butterflies, one finds that they do not, after blending, harmonise with the rest of the wing; thus it would appear that they probably have a different function from those found on the under wings, which it has been thought are for concealment.

Patterns have been considered as regards their powers of concealing form, against plain backgrounds only. Against mottled backgrounds, which probably are more common in nature, these powers of concealment are as effective, not because they may copy or be paintings of anything in the background (they may be), but because after blending they will cause the animal to fade into its surroundings.

Beyond the blending distance of a pattern, the question as to whether the pattern does or does not imitate some part of the animal's surroundings, does not come in: pattern can only be effective in concealing form by means of mimicry or protective coloration, within its blending distance; nevertheless, beyond blending distance, as has been seen, pattern still has powers of concealing form. It is possible that a given pattern may combine both these uses. Suppose AE (text-fig. 5, *3*) be the extreme distance at which animal A is visible, and AF be the distance at which the pattern blends, then within the circle FGH the animal

Text-figure 5.



1. Ground plan of apparatus for experiments with artificial patterns.

2. The same, modified for measuring the blending distance of the patterns of insects' wings.

Notes referring to 1 and 2.

B = backgrounds made of 'Velox' paper exposed for varying lengths of time.

C & C' = standard candles.

S & S' = screens of "Bristol" board painted black.

obj. = object to be examined.

G = glass plate on which is glued a small bead of cork to which the insect is pinned.

obs. = observer along the dotted line.

Using the following distances, an illumination is obtained not unlike that under a hedge on a dull day:—

C-S and C'-S' = 6 cm.
C-obj. and C'-obj. = 40 cm.
C-C' = 40 cm.
G-B = 20 cm.

will be protected from enemies by mimicking its surroundings, and within the ring defined by FGH and EIJ by means of protective pattern-blending. The relative importance of these two methods of concealment will be according to the likelihood of enemies finding their way into the two areas, and the chance will be as the relative size of the two areas: the central area will, however, be at a somewhat greater disadvantage, because the enemy in arriving there, must pass through the outer area, and in so doing may discover its prey before reaching the centre. The relative importance will also depend upon the eyesight of the enemy and the distance at which it commonly looks for its prey; those who have watched birds feeding upon insects have often remarked the long distances at which they can see their quarry. In order to illustrate the distance at which the patterns of insects blend, measurements were made in the case of sixteen insects, as shown in the following table.

It is obvious that the size of an animal must affect the size of its pattern: for instance, a pattern which blends at a few feet would be useless to an animal the size of the zebra. It appears, therefore, that it is necessary, whilst giving the blending distance of a pattern, to also state the size of the animal, and the relation of these two in the form of a ratio as is done in the table. Whether by comparing these pattern-blending ratios or indices, it is possible to separate animals presenting conspicuous patterns from those presenting inconspicuous ones, is beyond the scope of this paper. In the case of the insects examined, in some cases the dorsal surfaces of the wings have a high index, whereas the ventral aspects of the lower wings have all low indices, with the exception of the Queen of Spain Fritillary (*A. lathonia*). In this insect the high figure is probably due to the reflection of the candle-light from the "mirror" spots on the wing. It has been noted that the larger the pattern, the more effective the outline blending; on the other hand, the greater the blending distance of the pattern, probably the more conspicuous the animal: other things being equal, it follows, therefore, that a pattern may be so adjusted that the danger of it, short of blending, is counterbalanced by its concealing powers after blending. Finally, attention must be directed to one other aspect of these experiments. Deductions have been drawn from experiments carried out with the human eye: thus it is entirely a matter of opinion whether they would apply in the case of the eyes of animals. It is known that many animals are short-sighted compared with man, for instance, those of short stature and which for this reason have a near horizon: it may be that the lion at night cannot see the zebra's stripes until within close range. On the other hand, there is some evidence that in the case of certain birds, such as falcons, vision is more piercing than in man.

However, these deductions from experiments with the human eye are illustrated in the markings of animals' coats.

	Blending distance of pattern in cm		Area of wings in sq cm		Index	
	Dorsal surface of wings	Ventral surface of posterior wings	Of dorsal surface of wings	Of ventral surface of posterior wings	$\frac{A}{C}$	$\frac{B}{D}$
	A	B	C	D		
Small Copper (*Chrysophanus phlæas*)	680	50	1·5	0·8	453	62
Clouded Yellow (*Colias edusa*) ♂	1260	180	4·8	2·9	262	62
" " " ♀	1230	180	4·8	2·9	256	62
Orange Tip (*Euchloe cardamines*) ♂	650	280	3·5	1·8	186	155
" " " ♀	620	280	3·5	1·8	177	155
Swallow tail (*Papilio machaon*)	1250	550	9·0	4·8	139	115
Red Admiral (*Pyrameis atalanta*)	880	520	6·4	3·7	137	141
Marbled White (*Melanargia galathea*)	640	360	4·8	2·9	133	123
Pearl bordered Fritillary (*Argynnis euphrosyne*)	310	230	2·7	1·6	115	144
Speckled Wood (*Pyrarga egeria*)	390	360	3·5	2·1	111	171
Marsh Fritillary (*Melitæa aurinia*)	240	140	2·3	1·4	104	100
Small Tortoiseshell (*Vanessa urticæ*)	480	430	4·8	3·1	100	139
Large Tortoiseshell (*V. polychloros*)	680	380	6·8	3·5	100	109
Queen of Spain Fritillary (*A. lathonia*)	300	120	3·7	1·6	81	262
Grayling (*Satyrus semele*)	400	220	5·8	3·5	70	63
Silver washed Fritillary (*A. paphia*)	310	230	7·2	4·0	50	77

NOTE.—The Blending distances were measured under the experimental conditions illustrated in text fig. 5.

The Areas of the wings were estimated by the method of tracing on squared paper.

For comparison: chequered surface of black and white squares of 4 sq. mm. blended at 440 cm.

Conclusions.

(1) Obliterative shading in animals is sometimes effected by means of pattern-blending.

(2) The outlines of animals are frequently masked by the blending of patterns at or near their margins.

(3) Patterns having these effects are usually unlike the animal's surroundings and therefore cannot be of use in concealment by means of mimicry (using mimicry in the broadest sense of the word).

50. On some Land-Planarians collected in Western Australia and Tasmania by Members of the British Association for the Advancement of Science. By ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., Professor of Zoology in the University of London (King's College).

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During the visit of the British Association to Australia in 1914, exceptional facilities were afforded to those members who visited Western Australia and Tasmania for the collection of zoological material for future investigation. In Western Australia various zoological expeditions were most successfully organized by Professor W. J. Dakin, and in Tasmania similar excursions were admirably arranged and carried out by Professor Flynn. Some of these expeditions were devoted to the collection of marine animals, while on others the members who took part in them had ample opportunities for the investigation of the terrestrial invertebrates.

During my residence in Australia, many years ago, I had already paid particular attention to a section of the terrestrial fauna which I [1895 *bis*] termed "Cryptozoic," comprising those small animals, for the most part invertebrates, which habitually hide away beneath logs and stones, or under the bark of trees. This faunistic assemblage includes many lizards, frogs and toads, centipedes and millipedes, scorpions, spiders, Peripatus, insects of many kinds especially cockroaches- many slugs and snails, a large number of land-planarians, and, more rarely, land-nemertines.

Of the Land-Planarians, the species of which are more or less readily distinguished by their beautiful colour-markings, I have on previous occasions described many different kinds from Australia, Tasmania and New Zealand, while many others have been described by Messrs. Fletcher and Hamilton, Professor Baldwin Spencer and Mr. Thomas Steel. It was naturally, therefore, a great pleasure to have the opportunity of returning once more to my old pursuits and collecting again species that were long ago more or less familiar to me. In addition to these, however, several hitherto undescribed forms were met with, so that altogether we obtained three species in Western Australia and six in Tasmania.

From Western Australia only four species have hitherto been described, all by Mr. Steel [1901], and all three obtained by us appear to be new.

From Tasmania, Steel [1901 *bis*] gives a list of twelve species, six of which were originally described by myself. Of these twelve, the British Association party obtained three, together with one previously known only from Australia and two new ones.

By far the commonest species in Tasmania seems to be *Geoplana tasmaniana*, originally collected on the historic voyage of the 'Beagle' and described by Charles Darwin.

It is curious that so few Australian zoologists have concerned themselves with the study of the Land-Planarians. This is the more to be regretted inasmuch as the opportunities for collecting these animals are rapidly passing away with the clearing of the bush. Moreover, much remains to be done in the investigation of these and other Cryptozoic animals. The Land-Planarians, in particular, still demand thorough comparative anatomical investigation with a view to revising the generic classification. Thus von Graff [1899] has proposed the genus Artioposthia, based on material supplied by myself, to include certain forms with a remarkably complex copulatory apparatus, but until many more species have been anatomically investigated it is difficult to estimate the value of this suggestion and impossible to say in many cases to which genus a given species should be referred. For this reason I retain the generic name Geoplana in its older and wider sense.

I desire to express my great indebtedness, not only to our generous Australian and Tasmanian hosts, but also to those members of the British Association who were good enough to hand over to me the Land-Planarians which they collected.

A. *Species collected in Western Australia.*

GEOPLANA DAKINI sp. n.

When crawling, very long and narrow, as much as three or four inches in length; strongly convex dorsally, flattened ventrally; without longitudinal ridges. A well-grown specimen in spirit measures about 74 mm. in length by 3 mm. in width in the middle, and is approximately oval in transverse section. The eyes are arranged as usual. The peripharyngeal aperture is situated about the middle of the body; the pharynx when protruded in spirit is subcylindrical. I have been unable to make out the genital aperture.

In life the dorsal surface is pale yellow, mottled and striped with olive-brown; the ventral surface is white, without pattern, and the anterior tip is pink.

The colour-markings on the dorsal surface are typically arranged as follows:—There is a narrow median stripe of brown and on each side of it a band of clear yellow ground-colour of about twice the width. This is followed by a band of brown, less sharply defined than the median stripe and of about twice the width. We may call this the inner paired stripe; it is followed by a somewhat wider band of ground-colour mottled with minute brown specks, and then comes an outer paired stripe similar to the inner one. In life there is a fairly wide band of clear ground-colour visible on the dorsal surface outside each outer paired stripe, but in spirit this tends to be turned in by contraction, so that the outer paired stripe comes to lie at the margin of the dorsal surface. The degree of distinctness of the paired stripes varies considerably, and they sometimes tend to merge into the mottling that lies between them.

There are thus five narrow longitudinal dark stripes on the dorsal surface, and in this respect the species resembles the common *G. quinquelineata* of Eastern Australia, to which it is probably closely related. It differs from that species, however, in that the dark stripes are not placed at equal distances apart, and in this respect it agrees with *G. mediolineata* Dendy, var. *simularis* Steel [1901], from South and Western Australia. It differs from both these species, however, in the presence of the mottling between the inner and outer lateral stripes.

This species was common in the neighbourhood of the Mundaring Weir, near Perth, W.A., upwards of a dozen specimens having been collected by our party. I have much pleasure in naming it after my friend Professor W. J. Dakin, D.Sc., who did so much to bring about the striking success of our zoological expeditions in Western Australia.

GEOPLANA FLAVILINEATA sp. n.

When crawling, the dorsal surface is convex, the ventral flat; there are no longitudinal ridges. In spirit the ventro-lateral margins are rather prominent and the ventral surface may be concave. The larger of the two specimens in spirit measures 40 mm. in length by 3·5 mm. in width in the middle. The eyes are numerous, but it is difficult to make out their arrangement in spirit specimens. The peripharyngeal aperture is situated somewhat in front of the middle of the ventral surface, the genital a little nearer to the peripharyngeal than to the posterior extremity of the body.

In life the dorsal surface is dark olive-grey, or purplish, with five very narrow longitudinal stripes of pale yellow, not at all conspicuous. The ventral surface is yellowish white, without markings; and the horseshoe-shaped anterior tip is pink.

The colour-markings on the dorsal surface are seen, under a lens, to be arranged as follows in the most strongly marked specimen:—The very narrow median yellow stripe is edged on either side by a very narrow dark grey band: this is followed by a very narrow yellow stripe (the inner paired stripe), narrower and less distinct than the median stripe. Then comes a much broader band of finely mottled grey, bounded on the outside by another very narrow yellow stripe (the outer paired stripe). The outer paired stripe is much more distinct than the inner one and is accentuated by the presence of a very narrow, almost black edging to the broad band of dark grey, finely mottled ground-colour which lies outside it and extends to the ventro-lateral margin of the body.

The characteristic feature of the pattern seems to be the presence of five very narrow, pale yellow stripes on a dark background of finely mottled grey, the interval between the median stripe and the inner paired stripe being considerably less than that between the two paired stripes. In the specimen described above the inner paired stripe is almost obsolete, while the outer one is quite clearly defined; in the other specimen both paired stripes are equally strongly developed, but neither of them is nearly so distinct as the median stripe, and the outer one has only a feebly developed dark edging on the outside.

This species seems to be closely related to Steel's *Geoplana fusco-dorsalis* [1901], also found near Perth.

I have only two specimens, both of which were obtained in the neighbourhood of the Mundaring Weir.

GEOPLANA COMITATIS sp. n.

Body in life comparatively short and broad. Dorsal surface in life pale dusky yellow, with olive-brown stripe and mottling; ventral surface white or grey, without markings; anterior tip pink.

The arrangement of the pattern on the dorsal surface is as follows:—There is a narrow median dark stripe. The interval between this and the margin of the body is divided into three bands of about equal width, viz., an inner band of clear ground-colour, an outer band of clear ground-colour, and an ill-defined intermediate zone in which the ground-colour is thickly sprinkled with minute dark specks.

The eyes are arranged as usual. The peripharyngeal aperture is situated about the middle of the body and the genital aperture somewhat nearer to it than to the posterior end. There is, however, a good deal of variation in this respect, depending upon the state of contraction.

The body in spirit is rather short and thick, averaging about 25 mm. in length by 4 mm. in width in the middle; it is approximately oval in transverse section, with no trace of marginal ridges.

This species bears a strong resemblance to *Geoplana tasmaniana* Darwin, but may be distinguished by the following features. Although there is one pair of ill-defined, broad dorsal bands of brown mottling, very much as in *G. tasmaniana*, there never appears to be a marginal (or submarginal) mottling or stripe. The general colour of the dorsal surface in spirit specimens is much yellower than in *G. tasmaniana.* The body (in spirit) is thicker, less flattened dorsally, and much more rounded at the margins. Steel [1901 *bis*] has described a supposed variety of *Geoplana tasmaniana* which he calls *flavicincta*, which seems to come a good deal nearer to *G. comitatis* than the typical form. It seems to me hardly likely, however, that the West Australian species is really identical with the Tasmanian "variety."

I have eleven specimens of this species, all collected in the neighbourhood of Mundaring Weir. The specific name *comitatis* is given in allusion to the British Association.

B. *Species collected in Tasmania.*

GEOPLANA TASMANIANA (Darwin)*.

Planaria tasmaniana Darwin [1844].
Geoplana tasmaniana Fletcher & Hamilton [1887].
Geoplana tasmaniana Dendy [1893].
Geoplana balfouri von Graff [1899].
Geoplana tasmaniana Steel [1901 *bis*].

This certainly seems to be by far the commonest of the Tasmanian Land-Planarians, and it has been obtained from many widely separated localities. In September 1914 Dr. Nicholls collected a number of specimens on Maria Island, and it was also much the commonest species in the neighbourhood of the Great Lake, which some of us subsequently visited.

The following notes were made on living specimens from Maria Island:—"Eyes as usual. When crawling long and "narrow, but dorsal surface somewhat flattened as well as "ventral. Dorsal surface very pale yellow with very narrow "median stripe of dark grey or brown and two wider stripes of "the same colour but less intense. Ground-colour between "median and wide stripes minutely flecked with brown, also "fine marginal mottling of brown separated from wide dorsal "stripe by band of clear yellowish ground-colour. Colour of "stripes varies from olive-brown to reddish."

The marginal band of mottling may develop into a more or less distinct stripe and in spirit it becomes submarginal, visible from the ventral but not from the dorsal surface, so that there appear to be only three stripes on the dorsal surface (one narrow and two broad) and a narrow yellow margin.

Specimens when crawling measure about 45 by 3 mm. The largest specimens in spirit measure about 34 by 3·5 mm.

The shape of the body in transverse section, in spirit-specimens, is somewhat flattened both above and below and with slightly pronounced marginal ridges.

A colour variety, represented by two specimens from the neighbourhood of the Great Lake, is characterized by the intensification of the dorsal stripes, the darkening of the ground-colour between the median and paired stripes, and the disappearance of the marginal mottling. The following notes were made on these specimens during life:—"Dorsal surface dark brown, nearly "black, with narrow median black line and a broader supra-"marginal black band, separated from the median stripe [line] "by an intervening zone of dark brown. All these dark parts "appear at first sight as one very broad dark brown band, with a "narrow white margin on either side." In spirit the margins of the body are very pale brown, not white like the ventral surface.

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* [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature (Proc. 7th Int. Cong. Boston, 1907, p. 44 (1912)).—EDITOR.]

In another slight variety the intensification of the finely mottled ground-colour of the dorsal surface to form a pair of broad dorsal stripes does not occur.

Mr. Steel [1901 *bis*] has already pointed out that Professor von Graff [1899] was probably mistaken in refusing to accept my identification of this species with Darwin's *Planaria tasmaniana* and in proposing for it the new name *Geoplana balfouri.*

GEOPLANA QUINQUELINEATA Fletcher & Hamilton.

Geoplana quinquelineata Fletcher & Hamilton [1887].
Geoplana quinquelineata Dendy [1890, 1891, 1895, 1896].
Geoplana quinquelineata von Graff [1899].
Geoplana quinquelineata Steel [1901].

More than a dozen specimens were obtained from the neighbourhood of the Great Lake which seem to belong to this common and widely distributed Australian species. I at first considered them as representing a variety of *Geoplana tasmaniana*, in which the broad, inner, paired stripe on each side was broken up into two and the outer (marginal or submarginal) stripe obsolete, giving, together with the median line, five narrow longitudinal stripes, all on the true dorsal surface. The fact, however, that the animal (in spirit) is a good deal narrower, and at the same time less flattened, than *G. tasmaniana* has induced me to abandon this interpretation.

The specimens do not strike me as being quite typical examples of *G. quinquelineata*, for the inner paired stripe is about twice the width of either the median stripe or the outer paired stripe, but it is well known that *G. quinquelineata* is subject to a good deal of variation as regards the width of the stripes.

My notes on the living worm are very brief, as follows:—"Dorsal surface yellowish, with dark grey or brown stripes. "Ventral surface pale grey, without markings. Anterior tip "brown. Microscopic bluish or whitish specks appear under lens "on dorsal surface (?always). Eyes as usual."

In spirit the ground-colour of the continuous dorsal and lateral surfaces is light brown, and the lateral surfaces appear on either side of the narrow, white, creeping sole as a fairly broad band of this colour. All the dark stripes are visible from the dorsal surface only, the outer paired stripe being supramarginal. The body in section is oval, but somewhat flattened below. The largest specimen now measures 35 mm. in length by barely 3 mm. in greatest breadth.

This species has not previously been recorded from Tasmania.

GEOPLANA NICHOLLSI sp. n.

? *Geoplana diemenensis*, pars, Dendy [1894].
? *Artioposthia diemenensis*, pars, von Graff [1899].
? *Geoplana diemenensis* Steel [1901 *bis*].

This species was obtained on Maria Island by Dr. G. E. Nicholls and again at the Great Lake. The Maria Island specimens may be regarded as the types of the species. The Great Lake specimens differ but slightly.

The Maria Island specimens, in life, were considerably flattened even when crawling, but slightly convex above. Body tapering gradually in front to narrow, horseshoe-shaped tip. Posterior end bluntly pointed. Eyes as usual. Dorsal surface pale grey, finely mottled with dark brown, and with fine median dark brown stripe. Ventral surface pale grey, nearly white, without markings. Anterior tip light brown on both surfaces, or pinkish. A specimen, when crawling, measured 50 mm. in length by 4·5 mm. in greatest breadth (not far from the posterior end). When put in spirit the lateral margins turn in and become visible from the ventral surface as two narrow, mottled bands, one on either side of the broad creeping sole, forming two narrow lateral surfaces sloping downwards and inwards from the much flattened dorsal surface, which they join at an acute angle. In spirit the peripharyngeal aperture is situated not far from the middle of the body and the genital aperture rather nearer to it than to the posterior end.

In the spirit-specimens the mottlings have a distinct purple tinge and show a slight tendency to arrange themselves in six longitudinal bands on the true dorsal surface, three on each side of the narrow median dark stripe, the outer band on each side being close to the dorso-lateral margin. The largest spirit-specimen measures 32 mm. in length by 4 mm. in greatest breadth.

One of the Maria Island specimens was specially noted during life as being very dark brown dorsally. Narrow median stripe and mottlings still visible. In addition also microscopic specks of bluish white thickly dusted over dorsal surface.

The following notes were made on living specimens collected in the neighbourhood of the Great Lake:—" When at rest very " broad and much flattened on both surfaces. When crawling " long and narrow, with horseshoe-shaped anterior tip and pointed " posterior extremity. Eyes as usual. Dorsal surface pale grey " with narrow longitudinal stripe of dark grey-brown down the " middle, and thickly marbled with olive-brown, the markings "showing a slight tendency to longitudinal arrangement. Ventral "surface pale grey without markings, nearly white. Anterior tip "pinkish brown. Colour of dorsal markings reddish brown, "almost chestnut, in some specimens." In these specimens the tendency of the markings on the dorsal surface to arrange themselves in three longitudinal bands on each side of the narrow, mid-dorsal, dark stripe, is more marked than in the Maria Island specimens. These specimens also do not attain so large a size as those from Maria Island, measuring in spirit about 25 by 4 mm.

This species is evidently closely related to the Australian *G. quadrangulata*, especially to the mottled Mount Wellington (Victoria) variety of that species. It is, however, a very much more robust form *, being intermediate in this respect between *G. quadrangulata* and the Tasmanian *G. diemenensis*.

The relationship between these three species requires careful investigation. *G. diemenensis*, it may be remembered, is characterized by the presence of remarkable comb-like copulatory organs, and is accordingly included by von Graff [1899] in his genus Artioposthia. Such organs have not been observed in *G. quadrangulata* or in *G. nichollsi* †, but we must not overlook the possibility that all the specimens of these species hitherto found have been immature and that the peculiar copulatory organs may be developed only in full-grown individuals. The specimens of *G. diemenensis* in which I observed these organs were collected in February ‡ and March, while those of *G. nichollsi* described above were collected in September. The size of the specimens may also depend largely on the time of year. Unfortunately, we do not yet know nearly enough about the life-history of land-planarians to enable us to settle these points.

Steel has already expressed a doubt as to whether all the specimens originally referred by me to *G. diemenensis*, and accepted as such by von Graff, really belong to the same species. He himself gives a figure of a specimen of "*G. diemenensis*," one of a small series of examples from Trevallyn Hills and Table Cape, but I am doubtful whether it really belongs to that species — or yet to *G. nichollsi*, which it seems to resemble fairly closely in pattern—because the transverse section appears to be of quite different shape, not at all quadrangular. Possibly, however, the outline given represents the transverse section in life, which is very different from what it is in spirit-specimens.

In the type-specimens of *G. diemenensis* from Mount Wellington (Tasmania) there was no narrow median longitudinal stripe on the dorsal surface, and I am inclined to think that the presence of such a stripe in *G. nichollsi* may serve as a valid specific distinction.

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* I have, however [1895], described a robust variety of *G. quadrangulata* from the Blue Mountains, N.S.W.

† See, however, footnote below.

‡ This was one of the Parattah specimens, and as it shows a narrow, mid-dorsal, dark stripe, I strongly suspect that it may be a specimen of *G. nichollsi*.

G. nichollsi may approach pretty closely to the common *G. tasmaniana* in general appearance, but may be distinguished by the sharper dorso-lateral margins, the sides of the body being rounded off (in spirit) in *G. tasmaniana*.

GEOPLANA MORTONI Dendy.

Geoplana mortoni Dendy [1894].
Geoplana mortoni von Graff [1899].
Geoplana mortoni Steel [1901 *bis*].

We obtained a dozen good specimens of this beautiful and well-characterized species in September 1914, in the neighbourhood of the Great Lake. It had been previously obtained by the late Mr. Alexander Morton from an unknown locality in Tasmania, and by Professor Baldwin Spencer from Parattah, and my own acquaintance with it was limited to spirit-specimens.

The following observations were made on a living specimen:— "At rest very broad and much flattened, no median dorsal ridge. "Dorsal surface dull yellow, closely and finely mottled with chest "nut-brown. Horseshoe-shaped anterior tip brown. Eyes as "usual. Ventral surface white, much less closely mottled with "small brown specks, with very narrow marginal band free from "mottling. When crawling, dorsal surface very strongly arched."

A good-sized specimen when crawling measured about 50 mm. in length by 4·5 mm. in greatest breadth, and one of my specimens measures as much after preservation in spirit.

The shape of the body in spirit-specimens is characteristic; convex above and concave below, especially in the anterior portion; broader behind than in front; with prominent, narrow margins at the junction of dorsal and ventral surfaces.

GEOPLANA TYPHLOPS Dendy.

Geoplana alba Dendy [1892].
Geoplana typhlops Dendy [1894].
Geoplana typhlops von Graff [1899].

This curious eyeless species appears to be one of the commonest of the Tasmanian land-planarians. It has previously been recorded from Mount Wellington, Hobart and Parattah, and in September 1914 we obtained it near the Great Lake and on Maria Island (one small specimen). Some of the specimens in spirit develop a distinct narrow median ventral band, due to darkening of the rest of the ventral surface. I have already noticed this feature in my previous descriptions.

GEOPLANA FLYNNI sp. n.

I propose this species for four specimens collected by Dr. Nicholls on Maria Island, and have much pleasure in naming it after Professor Flynn of Hobart, who so successfully organized the zoological excursions for members of the British Association in Tasmania.

The worm when crawling is long and narrow, convex above and flat below. The ground-colour of the dorsal surface in life ranges from grey to yellow, but even in the grey specimens it becomes fairly bright yellow in spirit. Minute brown specks are sparsely scattered over the dorsal surface and tend to arrange themselves in a very narrow median stripe. The horseshoe-shaped anterior tip is brown or brownish pink, and the ventral surface nearly white, without markings. The eyes are arranged as usual. In spirit the body is narrow, more or less flattened, especially ventrally, and with fairly well pronounced lateral margins.

In one specimen (in spirit) the peripharyngeal aperture is .ated well in front of the middle of the body, and the genital aperture rather nearer to it than to the posterior end. This is the only one in which both apertures are visible, but in another the peripharyngeal aperture seems to be about central; but of course the position of the apertures is influenced by the relative state of contraction of the two ends of the body.

One of the four specimens is much larger than the other three, measuring in spirit about 32 mm. in length by a shade over 3 mm. in greatest breadth. The smaller ones in spirit measure about 19 mm. in length by 2·5 mm. in breadth. In life one of them measured about 32 by 2 mm.

I think that the specimen which I described [1892] under the name *Geoplana* sp., from near Hobart, probably belongs to this species. Von Graff [1899] referred this specimen to the Victorian *G. quadrangulata* var. *wellingtoni*, but there was very little justification for so doing, or, I fear, for my own comparison of it with *G. quadrangulata* and *G. ventropunctata*.

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EXHIBITIONS AND NOTICES.

October 26, 1915.

Prof. E. W. MACBRIDE, D.Sc., F.R.S., Vice-President, in the Chair.

The SECRETARY read the following report on the Additions made to the Society's Menagerie during the months of June, July, August, and September, 1915:—

JUNE.

The registered additions to the Society's Menagerie during the month of June were 249 in number. Of these 61 were acquired by presentation, 87 by purchase, 36 were received on deposit, 9 in exchange, and 56 were born in the Gardens.

The number of departures during the same period, by death and removals, was 161.

Amongst the additions special attention may be directed to:—

1 Pallas's Cat (*Felis manul*) ♂, from Tibet, and 2 Burrhel Sheep (*Pseudois nahura*) ♀ ♀, from the Himalayas, deposited on June 19th.

1 Hybrid Chapman's and Mountain Zebra (*Equus chapmanni* × *E. zebra*) ♂, born in the Menagerie on June 17th.

1 White-browed Wood-Swallow (*Artamus superciliosus*), hatched in the Menagerie on June 17th.

1 Lesser Double-collared Sunbird (*Cinnyris chalybeus*) from South Africa, presented by Alfred Ezra, F.Z.S., on June 12th.

2 White Storks (*Ciconia ciconia*), hatched in the Menagerie on June 8th.

A collection of Pheasants, including 3 Vieillot's Firebacks (*Lophura rufa*), 4 Himalayan Monauls (*Lophophorus impeyanus*), and others, purchased on June 5th.

2 Ocellated Turkeys (*Meleagris ocellata*), from British Honduras, deposited on June 21st.

JULY.

The registered additions to the Society's Menagerie during the month of July were 382 in number. Of these 260 were acquired by presentation, 34 were received on deposit, 45 in exchange, and 43 were born in the Gardens.

The number of departures during the same period, by death and removals, was 241.

Amongst the additions special attention may be directed to:—

2 Puma cubs (*Felis concolor*) and 1 Eyra Cat (*Felis eyra*), from Cordova, Argentina, presented by Wilfred A. Smithers, C.M.Z.S., on July 28th.

2 Californian Sea-Lions (*Otaria californiana*), from California, received in exchange on July 19th.

1 Eland (*Taurotragus oryx*), born in the Gardens on July 15th.

A large collection of Birds, mostly European, presented by Major Frank Johnson, F.Z.S., on July 19th.

A collection of North American Birds, received in exchange from the Zoological Society of New York on July 19th.

2 Buff-breasted Partridges (*Ptilopachys fuscus*), 9 West-African Quail-Finches (*Ortygospiza atricollis*), and other birds from Gambia, presented by Dr. E. Hopkinson, D.S.O., F.Z.S., on July 21st.

2 Chinese Starlings (*Sturnia sinensis*), new to the Collection, received in exchange on July 28th.

10 Common Rheas (*Rhea americana*), hatched in the Menagerie on July 18th.

1 Blackish Tortoise (*Testudo nigrita*), from Indefatigable Island, and 1 Baur's Tortoise (*T. galapagoensis*), new to the Collection, from Charles Island, deposited on July 29th.

1 Royal Python (*Python regius*), from West Africa, presented by Robert R. Jones on July 19th.

AUGUST.

The registered additions to the Society's Menagerie during the month of August were 129 in number. Of these 89 were acquired by presentation, 21 were received on deposit, 1 in exchange, 1 by purchase, and 17 were born in the Gardens.

The number of departures during the same period, by death and removals, was 115.

Amongst the additions special attention may be directed to:—

2 Orang-Utans (*Simia satyrus*), from British North Borneo, deposited on August 7th.

1 Rosy Minivet (*Pericrocotus roseus*), 1 Rufous-backed Shrike (*Enneoctonus erythronotus*), 1 Rufous-bellied Babbler (*Dumetia hyperythra*), 1 Green Iora (*Ægithina viridissima*), from India, all new to the Collection, presented by E. W. Harper, F.Z.S., on August 4th.

A collection of Mammals, Birds, and Reptiles, including a Korin Gazelle (*Gazella rufifrons*), a Crowned Duiker (*Sylvicapra coronata*), a Waterhouse's Genet (*Genetta poensis*), 2 White-necked Crows (*Corvus scapulatus*), a Long-nosed Crocodile (*Crocodilus cataphractus*), and a Moebius's Snake (*Elapechis *moebii*), the last-named new to the Collection, from the Northern Territories of the Gold Coast, presented by Capt. C. H. Armitage, C.M.G., D.S.O., F.Z.S., on August 18th.

SEPTEMBER.

The registered additions to the Society's Menagerie during the month of September were 115 in number. Of these 65 were acquired by presentation, 32 were received on deposit, 7 in exchange, 8 by purchase, and 3 were born in the Gardens.

The number of departures during the same period, by death and removals, was 123.

Amongst the additions special attention may be directed to: -

1 Ocelot (*Felis pardalis*), 1 Kinkajou (*Potos caudivolvulus*), 1 Fraser's Squirrel (*Sciurus stramineus*), 1 Spiny Tree-Porcupine (*Coendu prehensilis*), 1 Harris's Owl (*Gisella harrisi*), 1 Salmon's Tiger Bittern (*Tigrisoma salmoni*), and 4 Peruvian Ground Doves (*Chamæpelia cruziana*), from Ecuador, presented by E. J. Brook, F.Z.S., on September 25th and 29th. The three species of birds are new to the Collection.

10 Wilson's Birds of Paradise (*Schlegelia wilsoni*), from Waigiou, new to the Collection, deposited, and 2 of the same presented, by A. E. Pratt on September 1st and 8th.

1 Black Manucode (*Manucodia atra*), and 7 Red Birds of Paradise (*Paradisea rubra*), deposited on September 13th.

2 Red Birds of Paradise (*Paradisea rubra*), and 4 Rufous-crowned Ground-Doves (*Phlogœnas rufigula*), the latter new to the Collection, from Waigiou, purchased on September 16th.

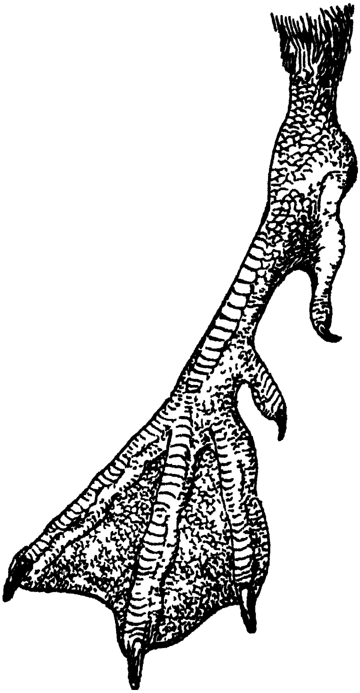
2 Chestnut-backed Finches (*Spermestes nigriceps*), new to the Collection, received in exchange on September 8th.

Mr. R. I. POCOCK, F.R.S., F.Z.S., Curator of Mammals, exhibited a series of burrows of trapdoor spiders from South Africa, belonging to types never previously brought to England. They were collected at Alicedale, near Grahamstown, by Messrs. F. Thurston and F. Cruden, and were given to Mr. Pocock by the former gentleman, who at the same time presented to the Society living examples of *Stasimopus* and *Gorgyrella*.

Mr. D. SETH-SMITH, F.Z.S., Curator of Birds, exhibited a living hybrid Swinhoe's and Silver Pheasant (*Gennæus nycthemerus* × *G. swinhoii*), which had been presented to the Society by Mr. H. J. Elwes, F.R.S. It was a male, and a very handsome bird, but, although somewhat resembling Swinhoe's Pheasant as regards the head and neck, the back, rump, and tail were of a chestnut-brown colour, differing from the males of both parent species. Mr. Elwes had also presented to the Society a young bird which he had bred from the above-mentioned hybrid, paired to a pure hen Swinhoe Pheasant, but this bird was not yet in adult plumage.

Mr. Seth-Smith also exhibited a male Mandarin Duck (*Æx galericulata*) bred in the Society's Gardens during the current year, in which an extra digit had grown from the inner side of the right tibiotarsal joint (text-fig. 1). He remarked that similar cases had been recorded by Bateson ('Materials for the Study of Variation,' page 394), but he believed that such abnormalities were rare, especially in birds other than those long domesticated.

Text-figure 1.



Right leg of male Mandarin Duck, with supernumerary digit.

November 9, 1915.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President, in the Chair.

The SECRETARY read the following report on the Additions to the Society's Menagerie during the month of October 1915:—

The number of registered additions to the Society's Menagerie during the month of October was 162. Of these 98 were acquired by presentation, 24 were received on deposit, 15 in exchange, 11 by purchase, and 14 were born in the Gardens.

The number of departures during the same period, by death and removals, was 206.

Amongst the additions special attention may be directed to:—

1 Hairy Tree-Porcupine (*Coendu insidiosus*), from Venezuela, presented by Hugo Pam, C.M.Z.S., on October 4th.

2 Larger-streaked Spider-hunters (*Arachnothera magna*), from the Himalayas, new to the Collection, presented by Alfred Ezra, F.Z.S., on October 1st.

1 Red-faced Crake (*Neocrex erythrops*), new to the Collection, presented, with a number of other birds from Venezuela, by Hugo Pam, C.M.Z.S., on October 4th.

1 Japanese Robin (*Erithacus akahige*), from Japan, and 1 Yellow-collared Ixulus (*Ixulus flavicollis*), from the Himalayas, both new to the Collection, deposited on October 13th.

1 Greater Amethyst Sunbird (*Chalcomitra amethystina*), from South Africa, new to the Collection, presented by Alfred Ezra, F.Z.S., on October 20th.

1 Sauvage's Tree-Frog (*Phyllomedusa sauvagii*), from Cordova, Argentina, new to the Collection, presented by Wilfred A. Smithers, C.M.Z.S., on October 20th.

Prof. H. MAXWELL LEFROY, M.A., F.Z.S., Curator of Insects, read a report on the House-Fly Investigations carried out during the present year in the Society's Gardens.

It is hoped that this report will be published in full in the 'Proceedings' for 1916.

Notes from the Caird Insect House.

Mr. C. J. C. POOL, Assistant Curator of Insects, read the following notes upon species recently bred and exhibited:—

ORTHOPTERA.

MANTIDÆ.

Sphodromantis guttata.

The female Mantid deposits her eggs in a case made of a gummy secretion. The eggs are in regular rows inside the case, which is attached to a twig or to the bark of a tree. There is an opening along the centre of the outer surface, each egg-cell being protected by a flap or door. The young emerge in a cluster and on reaching the exterior they remain suspended by threads or tubes for from 3 to 5 days. During this period they are incapable of seizing other insects or of feeding in the ordinary way, and yet they obtain sufficient nourishment to increase their size very considerably within a week. I have observed this development upon several occasions, and it is my opinion that we must regard the egg-case as a kind of feeding-bottle capable of supplying the young Mantids with liquid food, absorbed through the threads or tubes by which they are suspended until the first moult. After this important event they are active and are at last capable of an independent existence. To test my "feeding-bottle" theory I have on several occasions severed the connection between the young larva and the egg-case. The result was the same every time, and the creature died without further development.

I have examined several cases from which the young had emerged, and found that they all contained fluid matter which might form the necessary food, probably with the assistance of rain or dew.

The specimen referred to in a previous paper (P. Z. S. 1915, p. 289) lived from 6th July, 1914, until 24th September, 1915. On 19th August, 1915, it fractured a front leg, a mishap which reduced its chances of seizing a meal. Upon the third day following the accident, the Mantid surprised me by devouring the offending and still unsevered limb, after which it appeared to revive its interest in life by depositing an egg-mass, the eighth in its lifetime in the Society's Gardens. It died shortly after this event, having completed nearly fifteen months of active life.

Sphodromantis gastrica.

An egg-mass from Pretoria produced some young Mantids on 28th May, 1915. The majority of these died in the earlier stages. One fine female specimen, having devoured a number of her own kind and an abundance of other insect-food, arrived at maturity and developed her wings on October 18th, 1915, having occupied nearly five months in the process. This specimen is still alive and healthy, her food consisting principally of stick-insects. A few egg-masses produced numerous small Parasitic Hymenoptera (Chalcids) new to science, which when described will form the subject of another paper.

COLEOPTERA.

DERMESTIDÆ.

Thaumaglossa bimaculata Arrow.

Some Mantid egg-masses received from Pretoria in May 1915 were found to be inhabited by Coleopterous larvæ much resembling the museum pest *Anthrenus musearum.* The infested cases were isolated and kept under observation. The larvæ fed upon the contents of the egg-masses, and duly pupated within their own skins. The beetles have been emerging during September and October.

The genus *Thaumaglossa* is represented in the National Collection by eight species known to inhabit egg-masses of Mantids, their distribution being China, S. Australia, Nigeria, Rhodesia, and the Malay Peninsula. The insect now exhibited was examined by Mr. G. J. Arrow at the British Museum (Nat. Hist.) and has been described by him under the above name.

The type-specimen will be deposited in the National Collection and the co-type in the general reference collection now in course of formation in the Caird Insect House.

PTINIDÆ.

Ptinus pusillus Sturm.

This active little beetle is a well-known granary pest in France and Germany, but was not known to inhabit this country until 1906, when I discovered it in a corn-shop at Edmonton.

The female, which is more robust than the male and with shorter antennæ, has for some years been confounded with another species, *P. testaceus* Boield., in British works and collections.

I have taken both sexes in profusion in the Society's Gardens, and it is due to the study of the specimens collected there and at Edmonton that I have been able to clear up this old error.

Ptinus tectus Boield.

This beetle is another cosmopolitan granary pest, and during the last few years has become exceedingly common throughout this country. During last May a so-called insect-destroyer was recommended and submitted for test upon some Blow-fly maggots. It was not a success, its intended victims proving its ineffectiveness by simply pupating in a dish of the supposed deadly powder. The paper-bag containing the remainder was put aside in a cupboard in the Fly-room, and was forgotten until after the closing of the Fly Exhibition in September, when upon clearing out an accumulation of samples, etc., I noticed numerous small round perforations in the bag which had become slightly mouldy, and, upon peeling back the paper near the perforations, I discovered *P. tectus*, larvæ, pupæ, and imagos, perfectly healthy and apparently enjoying the novelty of breeding in an insect-killing powder, which actually appears to be a vegetable-meal upon which a corn-shop pest might be expected to thrive.

In conclusion, I must confess to a feeling of pleasure in recording the successful rearing of an African beetle new to science in the Caird Insect House, as well as the correction of an error which has caused considerable confusion in connection with the species of *Ptinus*. We have been handicapped by reduction of staff, our two helpers having joined the colours, otherwise we might have accomplished some other useful research-work with the aid of valuable living material received from various sources. Some day, under happier circumstances, we hope to be able to devote more attention to breeding, etc., thereby adding to the scientific value as well as to the popular interest of the Caird Insect House.

November 23, 1915.

Dr. A. Smith Woodward, F.R.S., Vice-President,
in the Chair.

Mr. R. W. **Harold** Row, B.Sc., F.Z.S., exhibited photographs of an interesting abnormal Frog (*Rana temporaria*), in which both posterior limbs lacked the hallux, though the calcar, or prehallux, was present on each side. The characteristic structure of the digits still existing clearly proved that the missing toe was the hallux, and dissection showed that there was no trace of it internally. All the other four digits were perfectly normal.

A complete description of this abnormality, with illustrations, will be published in the next part of the 'Proceedings.'

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[New names in clarendon type. Systematic references in italics. (z. s. l.) indicates additions to the Society's Menagerie.]

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No. 147.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

June 8th, 1915.

Dr. S. F. Harmer, M.A., F.R.S., Vice-President, in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The Secretary read a Report on the Additions to the Society's Menagerie during the month of May, 1915.

Mr. George Jennison contributed a note upon the "nest" made by a Chimpanzee in the Belle Vue Zoological Gardens, Manchester.

Dr. Cuthbert C. Christy, M.B., C.M., F.Z.S., remarked upon the temporary sleeping-platforms that he had seen made by Chimpanzees in the Ituri Forest.

Mr. Alfred Ezra, F.Z.S., exhibited a living specimen of Ricordi's Humming-Bird, which had been in his possession for about twelve months, and described his methods of feeding and exercising these birds, with which he had been so successful.

Mr. R. E. Holding exhibited several specimens showing variation in the horns of some local breeds of West African Humped Cattle.

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* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Mr. E. T. Newton, F.R.S., F.Z.S., exhibited two horns of the Sabre-horned Antelope (*Oryx leucoryx*), and remarked on certain peculiarities presented by them.

Mr. R. I. Pocock, F.R.S., F.L.S., F.Z.S., Curator of Mammals, read a paper on the feet, scent-glands, and other external characters of the Paradoxurine Viverrids, belonging to the genera *Paradoxurus*, *Arctogalidia*, *Arctictis*, and *Nandinia*, showing how these may be distinguished collectively from the Viverrine genera (*Genetta*, *Viverra*, etc.) and also how they may be differentiated from each other in the characters discussed.

Dr. A. Smith Woodward, F.R.S., V.P.Z.S., read a paper on the skull of an extinct mammal related to *Aeluropus*, obtained from a cave at the ruby mines, Mogok, Upper Burma, which he described as the type of a new genus and species.

Miss K. M. Parker, B.Sc., communicated a paper on "The Early Development of the Heart and Anterior Vessels in Marsupials, with Special Reference to *Perameles*."

In Marsupials, as in Eutheria, the pleuro-pericardial canals become continuous at an early stage, forming a horseshoe-shaped cavity lying round the anterior end of the embryo. The lateral endothelial tubes first arise in the hind brain-region and grow forwards. The anterior portion of the pleuro-pericardial cavity now increases rapidly in extent and its crescentic posterior wall, which forms the lip of the anterior intestinal portal, moves backwards as a whole, a process which brings about the lengthening of the foregut, so that the heart-primordia come to lie ventral to the closed gut. The heart-tubes are brought into contact with each other by the growth of the pericardium, which increases rapidly in antero-posterior length without any compensatory growth in width.

In the succeeding stages, the heart-primordia increase in length, and undergo curvature and differentiation into ventricular and auricular limbs. Complete fusion of the endothelial tubes does not occur till a relatively late stage, and proceeds in the antero-posterior direction.

The development of the aortic arches is typical, while the cardinal veins are derived partly from a vessel which lies close against the neural tube throughout its length and partly from more laterally situated capillaries.

Lieut. R. Broom, M.D., D.Sc., R.A.M.C., C.M.Z.S., sent a paper dealing with certain Triassic Stegocephalians. Restorations are given of the skulls of *Brachyops laticeps* Owen and *Bothriceps australis* Huxley, which are regarded as forming, with *Batrachosuchus browni* Broom, a distinct family, Brachyopidæ. *Bothriceps huxleyi* Lydekker is shown to differ from *Bothriceps* in the structure of the occiput, and in having numerous small teeth on the parasphenoid, pterygoids, and prevomers, and thus to belong to a very distinct new genus.

This Meeting closes the Session 1914–1915. The next Meeting of the Society for Scientific Business will be held on Tuesday, October 26th, 1915, at half-past FIVE o'clock P.M.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W.
June 15*th*, 1915.

No. 148.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

October 26th, 1915.

Prof. E. W. MacBride, D.Sc., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The Secretary read a Report on the Additions to the Society's Menagerie during the months of June to September, 1915.

Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, exhibited a series of burrows of trapdoor spiders from South Africa, belonging to types never previously brought to England. They were collected at Alicedale, nr. Grahamstown, by Messrs. F. Thurston and F. Cruden, and were given to Mr. Pocock by the former gentleman, who at the same time presented to the Society living examples of *Stasimopus* and *Gorgyrella.*

Mr. D. Seth-Smith, F.Z.S., Curator of Birds, exhibited a Mandarin Duck (*Æx galericulata*) in which an extra digit had grown from the inner side of the right intertarsal joint. He remarked that similar cases had been recorded by Bateson ('Materials for the Study of Variation,' page 394), but he believed that such abnormalities were rare, especially in birds other than those long domesticated.

Mr. Seth-Smith also showed a living hybrid Swinhoe's and Silver Pheasant, which had been presented to the Society by Mr. H. J. Elwes, F.R.S. It was a male, and a very handsome bird, but, although somewhat resembling Swinhoe's Pheasant as regards the head and neck, the back, rump, and tail were of a chestnut-brown colour, differing from the males of both parent species. Mr. Elwes had also presented to the Society a young bird which he had bred from the above-mentioned hybrid, paired to a pure hen Swinhoe Pheasant, but this bird was not yet in adult plumage.

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Mr. E. G. **Boulenger**, F.Z.S., Curator of Reptiles, read a paper on the feeding of Snakes in captivity, based on observations made upon specimens in the Society's Collection. The results showed that, with rare exceptions, snakes that refused to feed on dead animals were not more likely to accept them if alive.

Dr. S. F. **Harmer**, F.R.S., F.Z.S., read a preliminary paper "On Specimens of Cuvier's Whale (*Ziphius cavirostris*) from the Irish Coast."

The inclusion of *Z. cavirostris* in lists of the Cetacea of the British Seas appears to rest on the evidence of a single skull obtained by Sir William Turner from Shetland. By an arrangement made with the Board of Trade in 1912, the British Museum receives telegraphic reports of the stranding of Cetacea on the British Coasts. Two of the specimens thus reported have proved to belong to this rare species, and their skeletons have been secured for the Museum. One of these individuals, stranded in Co. Wexford on July 18, 1915, was ascertained to be a male, and it possessed a pair of massive teeth, about 1¼ inches in diameter and 1⅜ inches in length, at the anterior end of the lower jaw. The sex of the other specimen, which was stranded in Co. Cork on February 13, 1913, could not be ascertained, although its cranial characters point to its having been a female. The teeth were completely hidden beneath the gum, but dissection showed that two were present, in the same position as those of the male, but considerably smaller, their diameter only slightly exceeding half an inch. Casts of the lower jaws were exhibited. It was suggested that Cuvier's Whale is likely to prove less rare than has hitherto been supposed, as both specimens here recorded were at first believed to belong to *Hyperoodon rostratus*. It will be desirable to scrutinise carefully future records of "Bottle-nosed Whales," in the hope of ascertaining that some of them really belong to *Ziphius* or to the allied genus *Mesoplodon*.

Dr. F. E. **Beddard**, M.A., F.R.S., F.Z.S., Prosector to the Society, read a paper on Avian Cestodes entitled "On *Tænia struthionis* Parona and Allied Forms," in which he defined a probable new species of *Davainea* parasitic in the Ostrich (*Struthio masaicus*).

A paper was read from Mrs. **Mary G. Roberts**, C.M.Z.S., on the successful breeding and rearing of the young of a pair of Tasmanian Devils (*Sarcophilus harrisi*), kept in captivity at Hobart.

Professor S. J. HICKSON, M.A., F.R.S., F.Z.S., contributed a paper on some Alcyonaria and a Stylaster from the west coast of North America. Three new species of Alcyonaria were described therein.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 9th, 1915, at half-past FIVE o'clock P.M., when the following communications will be made:—

EXHIBITIONS AND NOTICES.

G. E. NICHOLLS, D.Sc.

Some Notes upon the Anatomy of *Rana tigrina*.

J. C. MOTTRAM, M.B. (Lond.).

(1) The Distribution of Secondary Sexual Characters amongst Birds, with relation to their liability to the Attack of Enemies.

(2) Some Observations on Pattern-Blending with Reference to Obliterative Shading and Concealment of Outline.

C. BODEN KLOSS, F.Z.S., F.R.G.S.

On a Collection of Mammals from the Coast and Islands of S.E. Siam, with an account of the Fruit-Bats by Dr. Knud Andersen.

Prof. W. J. DAKIN, D.Sc., F.Z.S.

Fauna of West Australia.—III. A new Nemertean—*Geonemertes dendyi*, sp. n.—being the first recorded Land Nemertean from Western Australia.

IV. *Palæmonetes australis*, sp. n., being the first record of the Genus in Australia.

The following papers have been received :—

G. A. Boulenger, F.R.S., F.Z.S.

(1) A List of the Snakes of East Africa, North of the Zambesi and South of the Soudan and Somaliland, and of Nyassaland.

(2) A List of the Snakes of North-East Africa, from the Tropic to the Soudan and Somaliland, including Socotra.

(3) Descriptions of a new Amphisbæna and a new Snake discovered by Dr. H. G. F. Spurrell in Southern Colombia.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W.
November 2nd, 1915.

No. 149.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

November 9th, 1915.

Dr. S. F. HARMER, M.A., F.R.S., Vice-President,
in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the month of October, 1915.

Prof. H. MAXWELL LEFROY, M.A., F.Z.S., Curator of Insects, read a report on the House-Fly Investigations carried out during the present year in the Society's Gardens.

Mr. C. J. C. POOL, Assistant Curator of Insects, read some notes upon a number of species which had been bred and exhibited in the Caird Insect House.

Dr. G. E. NICHOLLS read a paper containing an account of the anatomy of *Rana tigrina*, the so-called Bull-frog of India, and drew attention to certain features in which this species differs from its European congeners.

Dr. J. C. MOTTRAM read a paper on "Pattern-blending with reference to Obliterative Shading and Concealment of Outline." The paper recorded the results of laboratory experiments with

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artificial patterns. The experiments showed that obliterative, or counter-shading could be produced by blended black-and-white pattern, and that beyond the blending distance, interruptions at the margin of a pattern, or similarly placed eye-spots, blur the margins. The laboratory experiments were compared with actual patterns of animals.

Dr. MOTTRAM also read a paper "On the Distribution of Secondary Sexual Characters amongst Birds, with relation to their Liability to the Attack of Enemies." The paper was based upon a statistical enquiry into the possible existence of a correlation between these factors.

Mr. C. BODEN KLOSS, F.Z.S., F.R.G.S., contributed a paper on a collection of Mammals made by him on the coast and islands of S.E. Siam, over 500 specimens being obtained. One species and twenty-two subspecies were described as new.

Two papers, dealing with the Fauna of West Australia, were received from Prof. W. J. DAKIN, D.Sc., F.Z.S. The first paper contained the description of a new Land Nemertean, the first to be recorded from West Australia. The second paper described a new prawn-like Crustacean of the genus *Palæmonetes*, which genus had not hitherto been recorded in Australia.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 23rd, 1915, at half-past FIVE o'clock P.M., when the following communications will be made:—

EXHIBITIONS AND NOTICES.

G. A. BOULENGER, F.R.S., F.Z.S.

(1) A List of the Snakes of East Africa, North of the Zambesi and South of the Soudan and Somaliland, and of Nyassaland.

(2) A List of the Snakes of North-East Africa, from the Tropic to the Soudan and Somaliland, including Socotra.

(3) Descriptions of a new Amphisbæna and a new Snake discovered by Dr. H. G. F. Spurrell in Southern Colombia.

Prof. Arthur Dendy, D.Sc., F.R.S., F.Z.S.

On some Land-Planarians collected in West Australia and Tasmania by Members of the British Association for the Advancement of Science.

C. Tate Regan, M.A., F.Z.S.

The Morphology of the Cyprinodont Fishes of the Subfamily Phallostethinæ.

The following paper has been received:—

J. H. Lloyd, M.Sc.

Some Observations on the Structure and Life history of the common Nematode of the Dogfish.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W.
November 16*th*, 1915.

No. 150.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

November 23rd, 1915.

Dr. A. SMITH WOODWARD, F.R.S., Vice-President, in the Chair.

The Minutes of the last Scientific Meeting were confirmed.

Mr. R. W. HAROLD ROW, B.Sc., F.Z.S., exhibited photographs of an interesting abnormal Frog, in which both posterior limbs lacked the hallux, though the calcar, or prehallux, was present on each side. The characteristic structure of the digits still existing clearly proved that the missing toe was the hallux, and dissection showed that there was no trace of it internally. All the other four digits were perfectly normal.

Prof. ARTHUR DENDY, D.Sc., F.R.S., F.Z.S., read a paper on a collection of Land-Planarians made by members of the British Association in West Australia and Tasmania. Three species were obtained in West Australia, all of which proved to be new, and of six species collected in Tasmania, two were described as new.

Mr. G. A. BOULENGER, F.R.S., F.Z.S., gave an account of two papers containing lists of the Snakes of East Africa and Nyassaland, and of North-east Africa and Socotra, with keys to the identification of the genera and species.

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Mr. Boulenger also read a paper in which he described a new *Amphisbæna* and a new Snake discovered by Dr. H. G. F. Spurrell in Southern Colombia.

Mr. C. Tate Regan, M.A., F.Z.S., read a paper on the morphology of the Cyprinodont Fishes of the subfamily Phallostethinæ. He described the structure of these extraordinary little fishes from Johore, and particularly the differences in the priapium of the two genera he recognised.

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 8th, 1916, at Half-past Five o'clock P.M. The Agenda will be announced early in January.

The following paper has been received:—

Prof. E. B. Poulton, M.A., F.R.S., F.Z.S.

On a Collection of Moths made in Somaliland by Mr. W. Feather. With Descriptions of new Species by Sir G. F. Hampson and others.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,

Secretary.

Zoological Society of London,
Regent's Park, London, N.W.
November 30th, 1915.

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